# POWER

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## RUTTING the ROAD

By J. C. HAWKINS

IN traveling through the country one frequently sees the sign "Don't Rut the Road." It is simply a request that drivers of automobiles or other vehicles avoid driving in the same tracks as those who have passed before instead of making a new path and thereby keeping the whole roadbed smooth and hard.

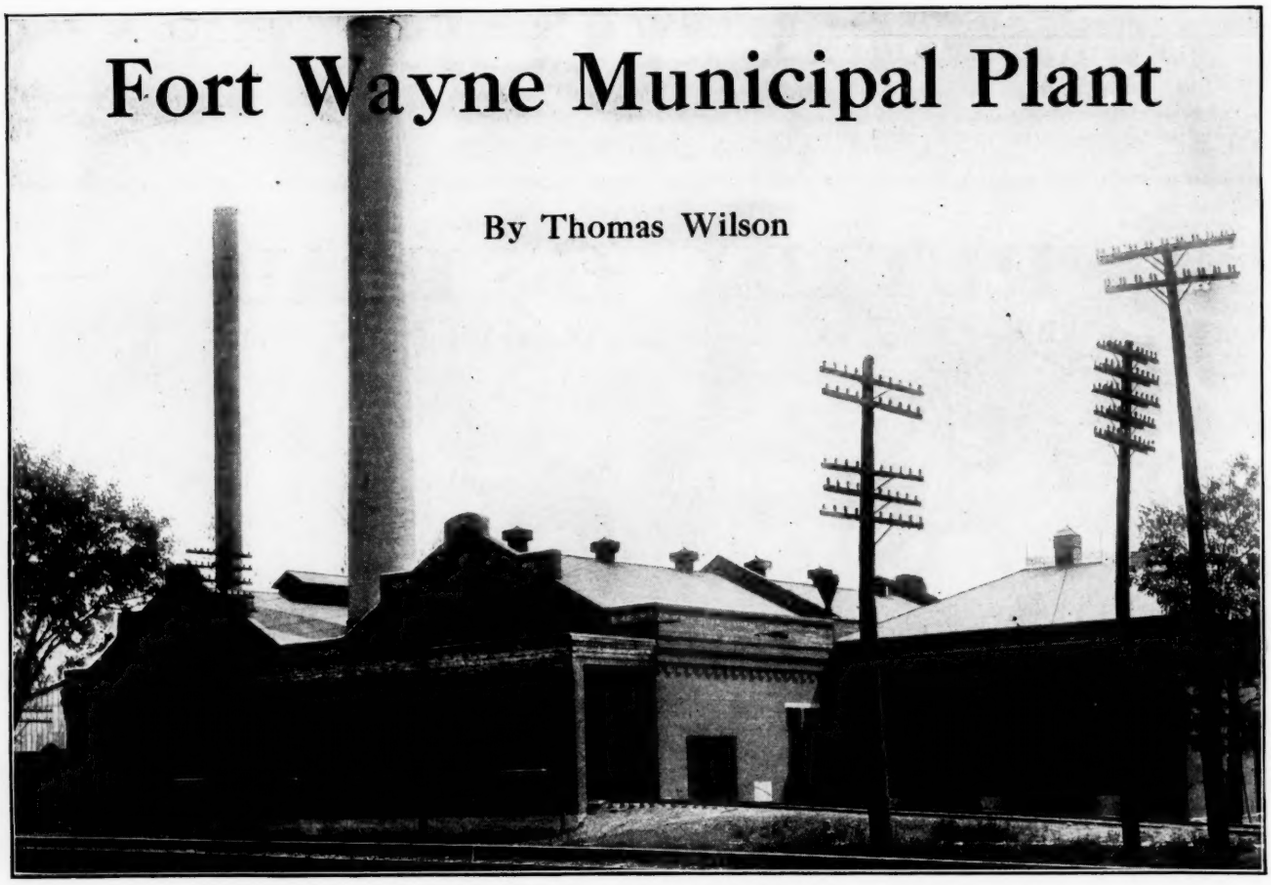
Many people are rutting life's highways by following in the tracks of others because it seems easier. They are willing to work in the grooves formed by the few pioneers who had to hew the path to reach the heights of their ambitions. It is easy to find workers to fill places which require no thinking, no mental effort, responsibility or originality, and the less the mental skill or physical effort required the more applicants there will be for the position.

One of the greatest drawbacks of the present day is the enormous amount of human energy and mechanical energy that are wasted because we are following in the ruts made by our ancestors. The engineer is less apt to "rut the road" than the average worker, primarily because the very nature of his work tends to make him a thinker; yet great achievements such as the steam turbine, the internal-combustion engine, the aeroplane, automobile and modern electrical apparatus are the work of but a comparatively few, and the majority seems willing to follow in the tracks of those few rather than think for themselves. It is not necessary for every man to be an inventor to be original. Everyone cannot be an Edison, a Westinghouse, Watt or Marconi, but there are innumerable little things that these great men have not touched upon but which the thinker will observe in applying the principles laid down by them. If you can do an unusual thing, an original thing; if you can do anything better than anyone else has done it the world needs you and will find you and make a path to your door.

It is originality, resourcefulness, new ideas and ability to successfully execute the ideas of others that count today, and the engineer who has these qualifications does not long want for a worthwhile job. Every employment office is full of trailers, rutters, failures and men who "never had a chance." Even the most rutty engineer has some good in him, and some good practical ideas of his own that might be of value if he would make them known. It is up to him, and his success will be measured only by his efforts.

# Fort Wayne Municipal Plant

By Thomas Wilson



*SYNOPSIS—A municipal light and power plant which in seven years has saved to consumers more than double their investment. The maximum lighting rate has been reduced from 10 to 7c. per kw.-hr., and before long the rate will probably be 6c. It is a steam-turbine plant with water-tube boilers having top-feed stokers.*

Should a municipality own and operate its electric-light and power plant? This question has been argued pro and con in the columns of *Power* and elsewhere for years. Adherents of either side have cited case after case to prove their contentions. Unfortunately, failures have not been uncommon, but the reason has in most cases been "politics." Where the possibilities of a municipal plant have been properly conceived, the installation made in accordance with standard engineering practice and the plant operated and controlled on a business basis, free of politics, the results have been advantageous. This has been made evident in Fort Wayne, which has a municipal plant with an enviable record. It has made good from the start, and this is generally recognized by the 90,000 citizens of the municipality.

At a general election in 1906 the people voted 4 to 1 to construct and operate their own electric light and power plant. Since 1898 taxes had been levied for the purpose, and by 1908 the sum of $175,000 was available. The original bid called for an outlay of $165,000. Construction was begun in 1907 and by August, 1908, the first energy was produced. The first equipment consisted of two 500-kw. vertical Curtis turbines, with Alberger surface condensers and engine-driven auxiliaries, three 300-hp. Lyons boilers served by Roney stokers and the usual equipment of reciprocating pumps and heater.

At the beginning current was distributed to all public buildings, including schools, and to 420 magnetite 4-amp. arc lamps for street lighting. To build up the commercial load a rate of 8c. per kw.-hr., as compared to 10c. charged by the privately owned central station, was introduced. The public-lighting and commercial load grew so rapidly that in 1910 it was necessary to install more equipment in the plant, consisting of a 400-hp. boiler and a 1500-kw. turbine, all of the same type as previously installed. In 1912 two 500-hp. Bass water-tube boilers, each served by two Detroit stokers, were added to the plant, and in 1914 another addition was made, consisting of a 3000-kw. horizontal G-E turbine, with an Alberger surface condenser having turbine-driven auxiliaries, and a 725-hp. Bass water-tube boiler served by two Detroit stokers. The ratio of active grate area to boiler-heating surface was 1 to 48. The larger and more modern equipment of the later installations added considerably to the economy of the plant and, coupled with an improving load factor, reduced the coal and likewise the cost per unit of electrical output. A city water-works pump is located in the plant and receives its steam at nominal cost from the generating station.

An exterior view of the plant as it now stands is shown in the leading illustration. Fig. 1 shows the vertical turbines, Fig. 2 the large horizontal turbo-generator, Fig. 3 a plan view of the station and Fig. 4 the latest boiler installation. In the plan view of the station it will be apparent that coal is delivered on a railway siding. From track hoppers opening into the boiler room the coal is loaded into industrial cars, which are raised to the proper

level by an elevator and pushed over the stoker magazines, the latter being of sufficient capacity for an eight-hour run. Water for the plant is stored in a near-by basin receiving its supply from Spy Run Creek. Concrete dams maintain the water level.

As previously stated, funds for the initial investment were obtained by levying a tax of varying rate from 1898 to 1912. As the funds accumulated, they were invested in city bonds and the interest credited to the electric-light fund. From 1912 all additional equipment and construction work was paid out of the earnings of the plant.

TABLE I. COST OF MUNICIPAL LIGHTING PLANT

| | |
|---|---|
| **Investment by City:** | |
| Raised by taxation | $269,039.73 |
| Appropriated from general fund of city | 67,000.00 |
| Total | $336,039.73 |
| **Cost of Plant:** | |
| Invested by city | $336,039.73 |
| Interest on bonds | 13,643.66 |
| Construction cost paid from earnings | 385,364.18 |
| Total cost of plant | $735,047.57 |
| **Cost of Construction:** | |
| Boiler-plant equipment | $79,363.75 |
| Boiler-plant buildings, fixtures and grounds | 26,302.34 |
| Steam-power plant, equipment | 182,773.75 |
| Steam-power plant buildings, fixtures and grounds | 39,469.54 |
| Distribution system | 182,915.76 |
| Municipal contract public-lighting system | 82,647.23 |
| Transformers | 48,393.66 |
| Meters | 74,608.84 |
| Commercial lamps | 3,008.63 |
| General office equipment | 5,874.11 |
| Stores, department, equipment | 2,853.07 |
| Cost of plant purchased | 2,800.00 |
| Miscellaneous equipment | 987.57 |
| Utility equipment | 3,049.32 |
| | $735,047.57 |

Table I gives the cost of the plant, the sources of the total investment and an itemized division of the cost. It will be evident that the city, from taxes and appropriations from the general fund at various times, invested $336,039.73 in the plant. Interest earned on the plant funds invested in city bonds amounted to $13,643.66, and the construction cost paid from earnings totaled $385,364.18, giving a grand total to June 30, 1916, of $735,047.57. This is divided between the various departments as indicated under the subhead "Cost of Construction." The first four items belong to the power plant proper. Boiler-plant equipment, totaling 3025 hp., cost $79,363.75, or $26 per horsepower; 5500 kw. of generating

TABLE II. CURRENT GENERATED FOR STREET LIGHTING AND COMMERCIAL SERVICE

| | Street Arc Service, Kw.-Hr. | Commercial Service, Kw.-Hr. | Total Service, Kw.-Hr. |
|---|---|---|---|
| 1909 | 281,569 | 474,755 | 756,324 |
| 1910 | 567,560 | 1,252,020 | 1,819,580 |
| 1911 | 627,880 | 1,832,600 | 2,460,480 |
| 1912 | 734,290 | 2,242,020 | 2,976,310 |
| 1913 | 714,860 | 2,463,303 | 3,178,163 |
| 1914 | 966,400 | 3,509,960 | 4,476,360 |
| 1915 * | 471,110 | 2,448,188 | 2,919,298 |
| 1915–16 | 955,550 | 5,359,750 | 6,315,300 |
| Total | 5,319,219 | 19,582,596 | 24,901,815 |

* First six months only, due to change of fiscal year to end June 30.

apparatus, $182,773.75, or $33 per kilowatt, and when the cost of buildings, fixtures (including switchboard, arc tubs, etc.) and grounds are included, the total cost of the power plant is $327,909.38, or a little less than $60 per kilowatt of generating capacity. This unusually low figure for a condensing plant gives no evidence of graft or misuse of funds, so common in municipal projects.

Prior to 1909 the city had been paying for its street lighting at the rate of $70 per arc per annum. Shortly after the municipal plant took over the service, this rate was reduced to $53 and has been maintained at this figure. With Fort Wayne growing rapidly, the demand for street lighting increased and the number of arc lamps jumped from 520, when the service was first taken over, to 865 at the present time. In addition there are 265 five-cluster posts in the business district, about 400 single standard mazda posts in the residential districts and a

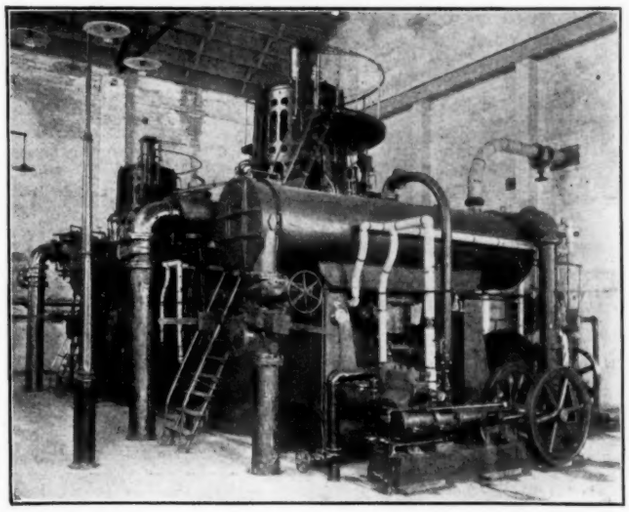


FIG. 1. TWO 500-KW. VERTICAL TURBINES

number of 300-watt series mazda nitrogen-filled lamps. In the future the type of lamp last mentioned will be used in preference to the arc.

Table II shows the increase in load from year to year, a maximum of 6,315,300 kw.-hr. being sold during the last fiscal year. This does not include 205,370 kw.-hr. used by the utility itself.

In January, 1914, owing to the growth of the business, the executive offices of the plant were moved from the controller's office in the city hall to an independent building. The mayor appointed a manager, J. Wessel, Jr., who was given full authority to select his department heads. A wonderfully efficient and enthusiastic organization was soon assembled and an active campaign started

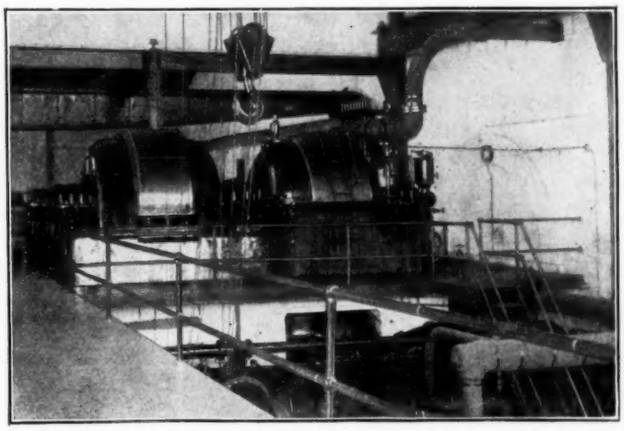


FIG. 2. THE 3000-KW. TURBO-GENERATOR

for commercial business, particularly a power load to fill in the valley during the day and thus improve the load factor. The result is shown in Table II. The peak load now runs as high as 3000 kw., and it is the intention to install another unit, possibly as large as 5000 kw., to give ample and efficient reserve and provide for

the ever-increasing demands. The plant now has 9000 active commercial consumers on its books, or more customers within the corporate limits of the city than its competitor. This figure may be compared to 3500 in 1913.

TABLE III. PRESENT TARIFFS

| | |
|---|---|
| First 50 kw. | $0.07 per kw.-hr. |
| Next 1,000 kw. | .05 per kw.-hr. |
| Over 1,050 kw. | .03 per kw.-hr. |
| Minimum charge. | .50 per mo. |

When monthly bill is $30 or over, a discount of 10 per cent. will be allowed, and an additional 10 per cent. when bill is over $125.

| Motors Under 10-Hp. Capacity | |
|---|---|
| First 50 kw. | $0.05 per kw.-hr. |
| Next 200 kw. | .04 per kw.-hr. |
| Over 250 kw. | .02 per kw.-hr. |
| Minimum charge. | .25 per hp. |

| Motors Over 10-Hp. Capacity | |
|---|---|
| First 350 kw. | $0.03 per kw.-hr. |
| Over 350 kw. | .02 per kw.-hr. |

Garages ..... Public, $0.03 per kw.-hr., private, 0.04 per kw.-hr.

In September of 1914 the maximum lighting rate was reduced to 7c. per kw.-hr.; and in February, 1916, application was made to the Public Service Commission to make another 1c. reduction, which no doubt will be granted, as even with the proposed rates the station would be more than self-supporting. The present tariffs for light and power are given in Table III.

From the city the plant receives $53 per year for each magnetite arc lamp, $21 per cost per year for the five-cluster mazda lamps and 5c. per kw.-hr. flat rate for the single incandescent standards. The total current produced in 1915-16 was 6,520,670 kw.-hr. Deducting 205,370 kw.-hr. used by the utility gives a net production of 6,315,300 kw.-hr., an increase of 25 per cent. over 1914-1915. Table IV summarizes the load and revenue for each field served during the past year. It will be seen that the revenue for commercial lighting averaged 4.7686c. per kw.-hr.; commercial power, 2.0538c. and municipal lighting, 3.8823c.

Coal for 1914-15 averaged 6.13 lb. per kw.-hr. For 1915-16 this unit figure was reduced to 5.7 lb., and it is estimated that the present coal consumption runs close to 5 lb., credit being given to the new boilers and stokers and the large turbine unit. The fuel used is Indiana nut and slack purchased at the mines at a cost averaging 85c. per ton. Adding a freight rate of 95c. makes the cost of the coal delivered $1.80 per ton.

Table V gives the annual cost of production from the time the plant began to generate energy. In the last column of this table are the costs per kilowatt-hour for the year 1915-16. The labor item of 0.2738c. per kw.-hr. covers the wages of 17 men required for three 8-hour shifts. The employees include a chief engineer, three switchboard attendants, three steam engineers, three firemen, three assistants, one oiler and wiper and three laborers. The coal cost is 0.5159c. per kw.-hr. This is figured on a basis of net kilowatts and does not take into account the current used by the utility. The coal required to

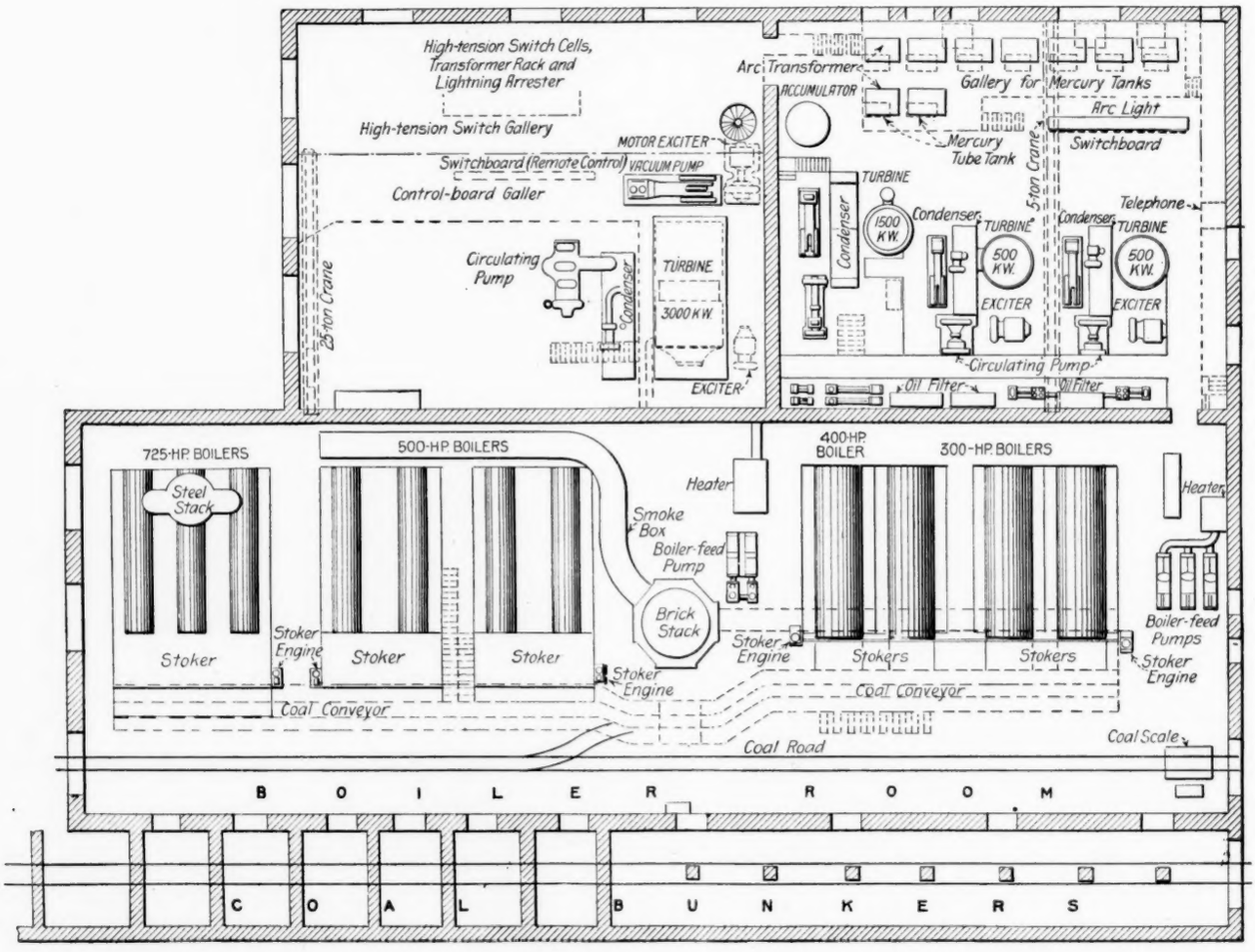



FIG. 3. PLAN VIEW OF THE FORT WAYNE MUNICIPAL STATION

TABLE IV. LIGHTING AND POWER REVENUE

| | Kw.-Hr. | Amount | Revenue, Kw.-Hr. |
|---|---|---|---|
| Commercial-light earnings | $3,668,945 | $174,956.69 | $0.047686 |
| Commercial-power earnings | 1,238,981 | 25,445.99 | 0.020538 |
| Municipal-light earnings | 1,407,374 | 54,638.44 | 0.038823 |
| Miscellaneous steam, water-works | ..... | 4,860.54 | ..... |
| Total operating earnings | $6,315,300 | $259,901.66 | $0.107047 |

generate steam for the water-works pump is also included and charged to the cost of production, so that some allowance should be made for these items. The charge for this service is included in the total revenue. In 1913 the fuel cost per unit was nearly 0.7c. and in 1914 a little less than 0.6c. As the same quality of coal was used, costing approximately $1.80 per ton, it is evident that the combustion efficiency is improving and there is hope of further reduction in fuel consumption.

TABLE V. ANNUAL COST OF PRODUCTION OF SWITCHBOARD

| Operating Costs | 1908–1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915* | 1915–1916 | 1915–1916 Kw.-Hr. Cost |
|---|---|---|---|---|---|---|---|---|---|
| Operating labor | $13,839.62 | $12,642.06 | $14,035.54 | $15,820.25 | $15,680.51 | $13,497.22 | $7,931.51 | $17,296.11 | $0.002738 |
| Fuel for steam | 18,518.45 | 20,408.78 | 23,848.48 | 30,433.73 | 22,041.81 | 26,346.21 | 12,965.66 | 32,578.48 | 0.005159 |
| Miscellaneous supplies and expenses | 1,376.14 | 1,624.22 | 1,172.21 | 1,690.43 | 2,257.11 | 887.95 | 433.19 | 514.71 | 0.000082 |
| Maintenance of plant, equipment, buildings, fixtures and grounds | 3,212.48 | 1,857.26 | 4,071.50 | 6,556.47 | 5,013.04 | 5,207.72 | 3,060.18 | 6,980.40 | 0.001105 |
| Total cost of production | $36,946.69 | $36,532.33 | $43,127.73 | $54,500.88 | $44,992.42 | $45,939.10 | $24,390.54 | $57,369.70 | 0.009084 |
| Total cost per kw.-hr | 0.0488503 | 0.0200773 | 0.0175273 | 0.0183115 | 0.0141585 | 0.0102626 | 0.00978 | 0.009084 | |

* First six months only due to change in fiscal year to end June 30.

Table VI gives the total expense and revenue. Every year shows a profit with the exception of the first, and this was due to an arrangement whereby the city paid the bills in lieu of the street lighting. If the city had been billed for service, as in the succeeding years, there would have been a profit instead of a deficit.

TABLE VI. TOTAL EXPENSE AND REVENUE

| | 1908–1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915* | 1915–1916 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Steam power generation | $36,946.69 | $36,532.33 | $43,127,73 | $54,500.80 | $44,992.42 | $45,939.10 | $24,390.54 | $57,369.70 | $343,799.39 |
| Distribution | 2,766.67 | 2,845.65 | 5,216.14 | 6,438.39 | 8,565.50 | 9,909.00 | 4,034.40 | 10,269.01 | 50,044.76 |
| Consumption | 3,812.27 | 5,503.23 | 6,321.66 | 9,699.06 | 14,844.49 | 13,174.15 | 8,036.22 | 17,730.74 | 79,121.82 |
| Commercial | 200.00 | 356.99 | 960.18 | 811.65 | 1,567.69 | 5,087.79 | 4,095.50 | 11,472.04 | 24,551.84 |
| General | 60.00 | 314.83 | 451.71 | 588.24 | 1,754.41 | 8,751.43 | 3,766.31 | 12,144.63 | 27,831.56 |
| Depreciation | | | | | | 24,115.35 | 13,284.90 | 29,658.99 | 67,059.24 |
| Undistributed | 2,062.60 | 1,839.69 | 2,158.50 | 1,396.39 | 9,116.04 | 6,050.47 | 2,677.10 | 9,850.30 | 35,151.09 |
| Contingencies | | | | | 6,501.90 | | 249.93 | 4,391.98 | 11,143.81 |
| Total operating expenses | $45,848.23 | $47,392.72 | $58,235.92 | $73,434.61 | $87,342.45 | $113,027.29 | $60,534.90 | $152,887.39 | $638,703.51 |
| Total operating revenue | 41,105.27 | 76,317.54 | 103,900.36 | 117,854.80 | 132,045.00 | 178,211.43 | 107,596.10 | 259,901.66 | 1,016,932.16 |
| Net operating revenue | | $28,924.82 | $45,664.44 | $44,420.19 | $44,702.55 | $65,184.14 | $47,061.20 | $107,014.27 | $378,228.65 |
| Net operating deficit | $4,742.96 | | | | | | | | |
| Net kw. production | 756,324 | 1,819,580 | 2,460,480 | 2,976,310 | 3,178,163 | 4,476,360 | 2,919,298 | 6,315,300 | |
| Cost per kw.-hr. | $0.0606 | $0.0260 | $0.0236 | $0.0246 | $0.0274 | $0.0252 | $0.0242 | $0.0242 | |
| Revenue per kw.-hr. | .0543 | .0419 | .0422 | .0395 | .0415 | .0398 | .0431 | .0411 | |

* First six months only, due to change in fiscal year to end June 30.

Up to 1914 no depreciation had been charged, the surplus being reinvested in plant improvements and additions to the capacity. After this date the amounts tabulated have been entered on the expense side of the ledger. No interest on the money invested or taxes appear in the records. These items must be considered when comparison is made with privately owned plants otherwise there would be a discrepancy.

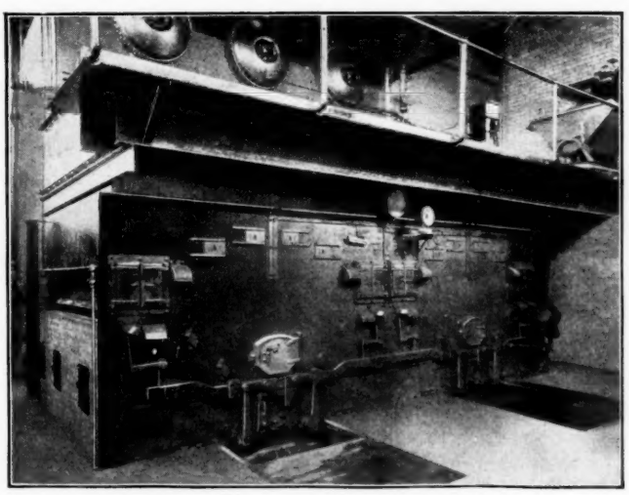


FIG. 4. THE 750-HP. BOILER LAST INSTALLED

In the seven years the city plant has been in operation it has saved its patrons $390,000 over existing rates at the time of its inception, a reduction of approximately 30 per cent. In forcing the privately owned plant to meet its rates, this saving to the citizens of Fort Wayne is more than doubled, for until the last year or so the competing company had the greater number of customers. The gain then in seven years is easily $800,000, which may be compared to the $336,039.73 actually invested by the city, the balance of the total expenditure having been paid from earnings of the utility. In other words, the citizens have been saved considerably more than double their original investment. The utility has no bonded or other indebtedness. It has been making large profits annually, and there is every prospect of a further reduction in rates.

## Extension of Buffalo Power Station

The engineers on the design and construction of the new power station of the Buffalo General Electric Co. are at work on the details for the new 35,000-kw. extension, and it is expected that actual construction will be commenced as soon as weather conditions permit. The present turbine room is large enough to contain the new 35,000-kw. Curtis turbine generator, but the boiler room will have to be extended to contain the entire new equipment of five 1140-hp. boilers which has been ordered. Three of these boilers can be accommodated in the present boiler room and are expected to be in operation early in the fall. Until the new generator is installed, these boilers will serve principally as relays for the present five boilers supplying steam for the initial installation of 60,000 kw. The two additional boilers will be placed in an extension of the present boiler room and this is the building construction referred to.

The new boilers are similar in type and arrangement to those at present installed, being of the B. & W. type fired from both ends by means of two Riley stokers having 15 retorts each. The boiler settings are the largest of the type yet installed and are approximately 25 ft. wide by 18 ft. deep. The present stokers are engine-driven through countershafts, but the new boilers will be turbine-driven and will be direct-connected by chain drives.

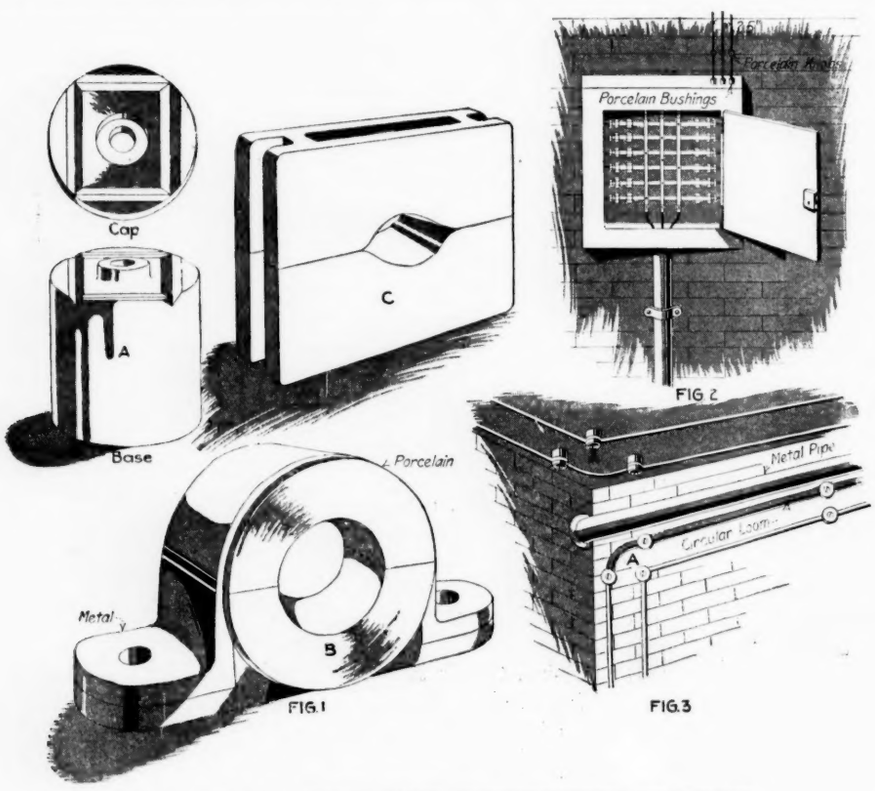
# The Installation of Motors—IV

By R. Thistlewhite

*SYNOPSIS—The installation of a 15-hp. 220-volt two-phase motor in a building of open-mill construction is taken up, showing how to do this work according to the requirements of the National Board of Fire Underwriters' rules.*

The machine to be installed is a 15-hp. two-phase three-wire induction motor. The installation is to be made in a nonfireproof building of open-mill construction, the beams being spaced about 4 ft. apart. The supply is obtained from the floor on which the motor is installed, and the wires are to be run on knobs.

Although the code will allow all wires of No. 8 B. & S. or over, to be attached to solid knobs, it is easier to make the installation with split knobs, and this will result in a saving of time and material. Split knobs are made in all sizes; however, those with one supporting screw can be used only for wires up to No. 4 B. & S. For conductors larger than this, knobs must be used that are made for two supporting screws and arranged to be supported in an iron mounting as shown at *B* in Fig. 1. The knob shown at *A* in Fig. 1 has four grooves in the base and four in the cap, each of a different size, and any groove in the cap can be made to coincide with any groove in the base, making the same knob adaptable for any size of wire from No. 10 to No. 00, although the Board of Fire Underwriters will not allow this knob to be used for a wire larger than No. 4 B. & S. There is a type similar to *A*, Fig. 1, but smaller, which will accommodate wires from No. 18 to No. 6.




FIGS. 1 TO 3. SHOW SOME CONSTRUCTION FEATURES

Fig. 1—Types of porcelain knobs. Fig. 2—Panel box. Fig. 3—Method of installing wires near foreign conducting materials, and right-angle bends made with three knobs

Before beginning the actual installation of the motor and wiring, there are several values which must be either calculated or taken from the name-plate of the machine. The most important of these will be the amount of current required to operate at full load, 25 per cent. overload, and starting. The first of these values will be found on the name-plate or can be calculated from the formula $I = \frac{hp. \times 1000}{2E}$, where $I$ equals the current in amperes, $E$ the voltage the motor is designed for, and $hp.$ the rated horsepower of the motor. In this case the full-load current $I = \frac{15 \times 1000}{2 \times 220} = 34$ amperes.

The second item required is to take care of any overload the motor may be called upon to supply, and is quoted by the underwriters as 25 per cent. of the full-load current. The current required in this problem at 25 per cent. overload is equal to $\frac{125 \times 34}{100} = 42.5$ amp. Table I gives the average starting current required by different sizes of alternating-current motors when started by means of an autostarter. This table must not be taken as absolute. It is inserted in the code as a suggestion only, to give an idea about what values may be expected for starting current, which in this case will be 200 per cent., or, $\frac{200 \times 34}{100} = 68$ amperes. The amount of current required for starting an alternating-current motor is made a fairly liberal allowance, therefore it is unlikely that it will exceed this amount; consequently a 100-amp. switch and fuse block will be large enough; this is 32 amp. larger than the actual calculated value. The starting current will be required only for the short time of accelerating the load, when its value will drop to the amount required by the motor to drive the load. The values given apply only to the current flowing in the two outside wires of the circuit. It will therefore be necessary to calculate the amount that will be delivered over the middle wire, so as to find the correct size of this conductor. In a balanced two-phase three-wire system the current in the middle wire is equal to 1.4 times that supplied by the outside wires. Hence the different values may be written:

TABLE I. PERCENTAGE OF FULL-LOAD CURRENT TAKEN AT STARTING BY ALTERNATING-CURRENT MOTORS

| Full-Load Rating, Amperes | Per Cent. Full-Load Rating |
|---|---|
| 1 to 30 | 250 |
| 31 to 60 | 200 |
| 61 to 100 | 150 |

Full-load current, 34 amp. × 1.4 = 48 amp.; 25 per cent. overload, 42.5 amp. × 1.4 = 60 amp.; starting current, 68 amp. × 1.4 = 96 amperes.

It is on account of the starting current that the insurance companies make an allowance in the protection of wires used to connect alternating-current motors. For instance, rubber-covered wires when used for any purpose other than for alternating-current motors, will have to conform with column A, Table II, which would make the size of wire for the foregoing amperes (68 and 96) a No. 4 for the outside wires and a No. 1 for the middle wire, which will be properly protected by 70- and 100-amp. fuses respectively. Alternating-current motors, using either rubber-covered or weatherproof conductors, may be fused up to the values given in column B. To determine the size of wire for an alternating-current motor, use the value given under the heading "Column B, Other Installations"; find a value which will include the start-

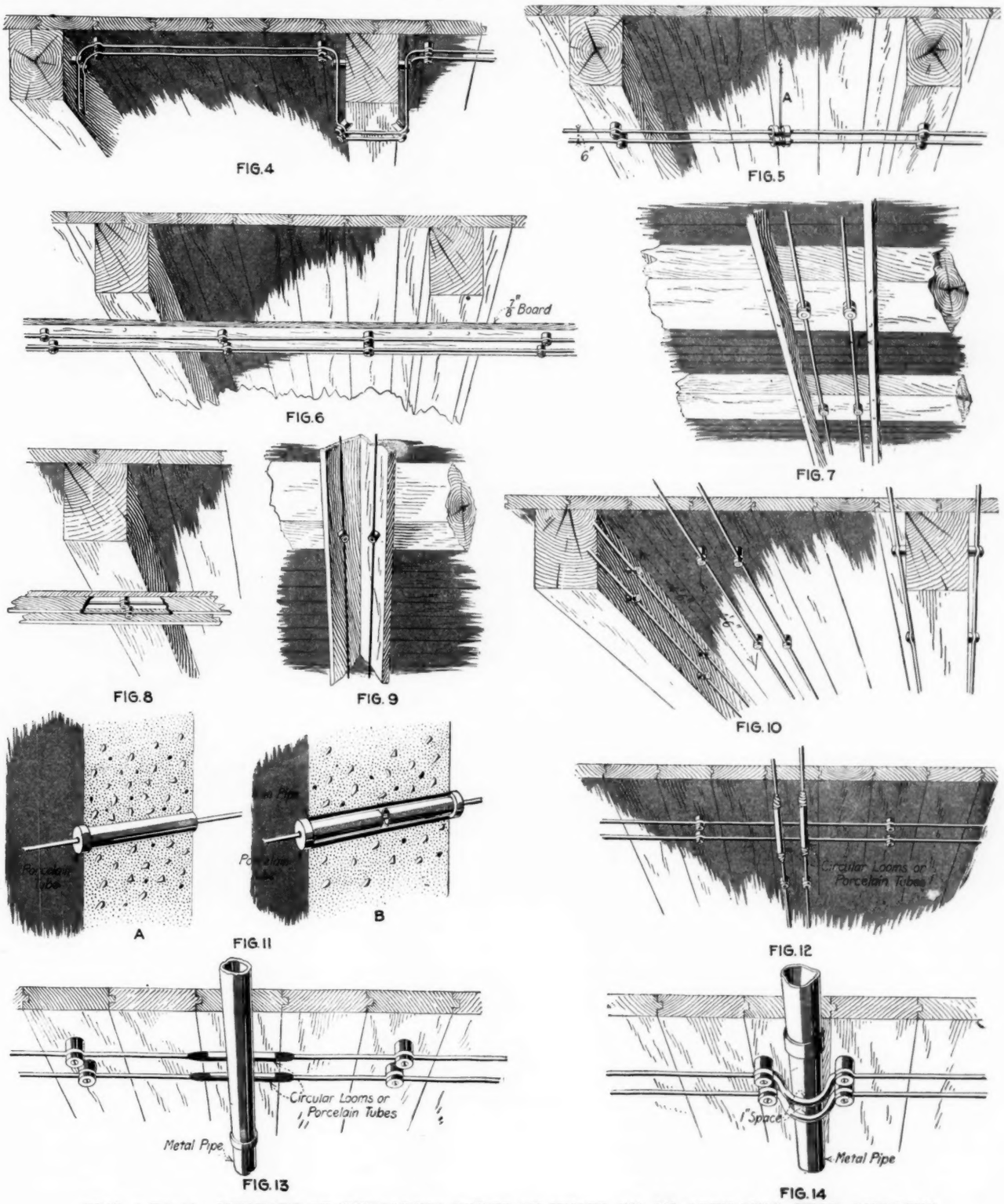



FIG. 4. FIG. 5. FIG. 6. FIG. 7. FIG. 8. FIG. 9. FIG. 10. FIG. 11. FIG. 12. FIG. 13. FIG. 14.

FIGS. 4 TO 14. METHODS OF INSTALLING WIRES ON KNOBS ON AN OPEN-MILL TYPE BUILDING

ing current of the motors, in this case 68 and 96 amperes respectively. Opposite these values will be found the correct sizes of wire, or in this case a No. 6 for the outside wires and a No. 3 for the middle wire.

The foregoing calculations are the same for all induction motors except that in a single-phase or three-phase circuit all wires in the circuit are the same size and the formula to find the value of the full-load current is: For single-phase, $I = \frac{hp. \times 1000}{E}$ and for three-phase, $I = \frac{hp. \times 1000}{E \times 1.732}$.

Assume that there is, in the power panel box on the floor where the motor is located, a circuit that can be used for the supply. Furthermore, assume that the

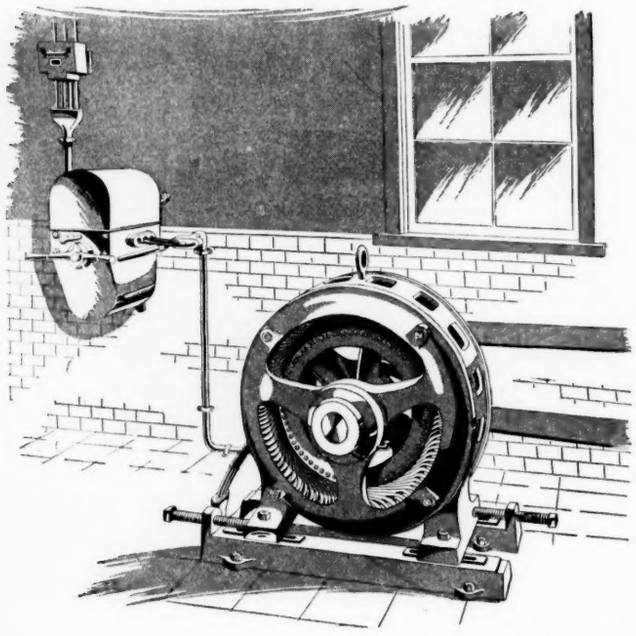


FIG. 15. TYPICAL INDUCTION-MOTOR INSTALLATION

panel box is made of iron and is of the surface type. The wires will be brought out through holes in the top of the box, bushed with porcelain bushing. Beginning the run of wires at the panel box, three knobs are placed in position about two or three inches from the entrance holes, and spaced so that when the wires are attached to the knobs they will be at least 2.5 in. apart, as shown in Fig. 2.

Right-angle bends can be made either on two or three knobs, three being preferable, giving a better mechanical support and presenting a much neater appearance, as at *A* in Fig. 3. The separating distance 2.5 in. must be maintained between wires and also between the wires and any other conducting material which may be encountered, such as electric-lighting and signal circuits, iron beams, girders and gas pipes. If for any reason this cannot be done, the spacing need not be maintained, but the wires must be run in circular loom for the entire length that runs parallel to the foreign conducting material, also shown in Fig. 3.

When wires are run open in a building of mill construction, they must be run around the beams as shown in Fig. 4 unless they are larger than No. 6, under which condition they may be spaced 6 in. apart and supported on the under side of the beam, as in Fig. 5. Should the beams be spaced too far apart to give proper mechanical support to the wires without undue sag, an additional support will have to be used and can be made by placing a hook in the under side of the flooring board and suspending a porcelain knob on a wire through the center of which the circuit conductor is passed, as shown at *A*, Fig. 5. In rooms having low ceilings with open-beam con-

TABLE II. CARRYING CAPACITIES OF RUBBER-COVERED AND WEATHERPROOF WIRES

| Wire Sizes, B. & S. Gage | Area Circ. Mil. | Column A, Rubber-Covered, Amperes | Column B, Other Insulations, Amperes |
|---|---|---|---|
| 14 | 4,107 | 15 | 20 |
| 12 | 6,530 | 20 | 25 |
| 10 | 10,380 | 25 | 30 |
| 8 | 16,510 | 35 | 50 |
| 6 | 26,250 | 50 | 70 |
| 5 | 33,100 | 55 | 80 |
| 4 | 41,740 | 70 | 90 |
| 3 | 52,630 | 80 | 100 |
| 2 | 66,370 | 90 | 125 |
| 1 | 83,690 | 100 | 150 |
| 0 | 105,500 | 125 | 200 |
| 00 | 133,100 | 150 | 225 |
| 000 | 167,800 | 175 | 275 |
| 0000 | 211,600 | 225 | 325 |

struction, or even in lofty rooms which are used for purposes that endanger the wiring, the foregoing arrangement cannot be followed unless the wiring is properly protected against injury.

Approved methods of protecting open wires are shown in Figs. 6 and 7. The first method, Fig. 6, consists of nailing a ¾-in. backboard about 2 in. wider than the wiring to the under side of the beams. On this board are placed the knobs. The second method, Fig. 7, is running a strip of ¾-in. board just high enough to project a little above the wires, which are run on the beams, the strips being nailed along each side of the wires about 1 in. away. The foregoing applies only to places that are dry or fairly dry. Should this not be the case, the running-board method must be used with sides as shown in Fig. 8, each piece being painted with waterproof insulating paint before being put together or installed. The construction shown in Fig. 9 may also be used.

For wires running in the same direction as the beams, they can be strung on the under side of the flooring or on the sides of the beams. When placed on the sides of the beams, it is preferable to run only one wire on one side of a beam, unless the beam is wide enough to properly space the wires without the inside one coming too close to the ceiling. A better method is to run one wire on each side of the beam, if it is not convenient to use the floor or separate beams. Fig. 10 shows three different constructions. Whichever method is used, the proper spacing must be maintained throughout the entire installation, the distance between supports not exceeding 4.5 ft. (Fig. 10) or closer if this is not sufficient support, which will be the case at corners and offsets.

Wires passing through partitions must be inclosed in porcelain tubes long enough to bush the hole for its entire length, as shown at *A*, Fig. 11. These tubes can be obtained in sizes large enough for all wires and in lengths from 1 to 24 in., which will accommodate most partitions encountered. There are, however, building walls which may have to be passed through that run from 3 to 4 ft. thick; in such cases they cannot be bushed by one tube. To take care of this condition first, bush the hole with a piece of pipe and then the pipe with two porcelain tubes, one inserted from each end so that they touch or nearly so in the center *B*, Fig. 11. If they do not touch, the space must not be so great that there will be any

possibility of the wire coming in contact with the pipe bushing.

Coming to the motor end of the run, there are two ways in which the wiring can be brought down to the machine: First, by mounting the starter on the side wall as in Fig. 15, and then by means of conduit from the starter to the motor. The two ends of the pipe must be properly equipped with condulets or other suitable fittings—bushings for this purpose are not allowed. Second, by erecting a 1-in. board wide enough to hold all wires properly spaced from the floor to the ceiling, close to the machine. If the controller is also placed on this upright, it will have to be wide enough for the base without projecting over the side of the board and mechanically strong enough to support the starting device.

All splices must be of the Western Union type, properly soldered and insulated by taping with rubber and friction tape. The splices should be so located that they will not come inside of a tube or a knob, otherwise it will be difficult to make the wire fit its support. The knobs may be fastened either with screws or with nails; if the latter are used, they must enter the woodwork at least one-half the thickness of the knob used and have leather washers under the heads so that the knobs will not be cracked or otherwise injured in driving the nails tight.

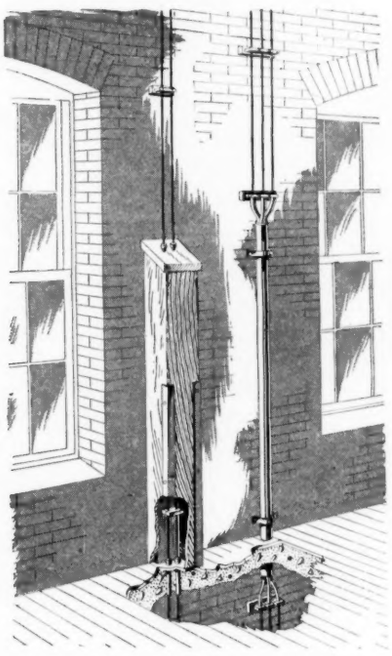
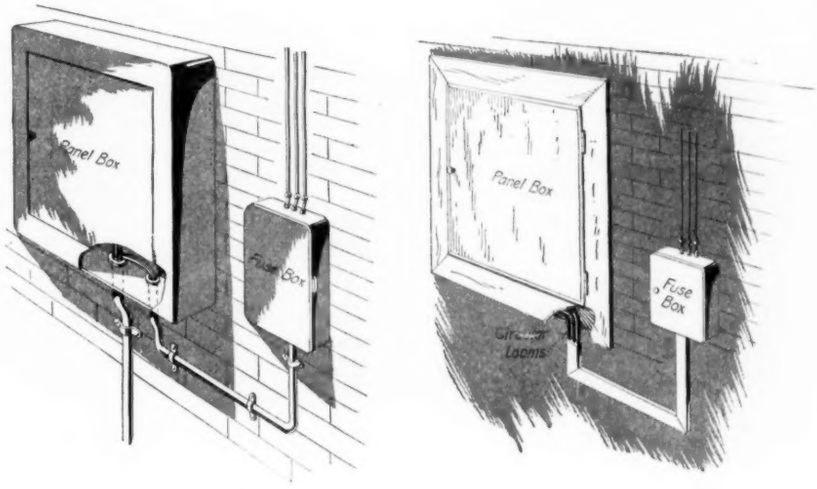


FIG. 16. PROTECTING WIRES WHEN RUN UP SIDE WALLS

Where wires cross each other, they must be separated either by loom or by tubes (Fig, 12), the latter being the best way, and the only way in damp places. Crossing over pipes can be done in the same manner as for wires, as shown in Fig. 13, excepting that it is always preferable to pass over rather than run under the pipe. This is not always possible, therefore when the wire is passed under the pipe an air space of one inch should be left, so that should the pipe sweat the moisture will have an opportunity to dry out (Fig. 14).

Where wires are run on side walls, they must be protected from injury for at least 7 ft. from the floor. This may be done by surrounding them with a wooden boxing of ⅞-in. material, leaving at least an inch space between the wires and the woodwork. The cover is placed on an angle to prevent it from being used as a shelf, and the wires are brought out through porcelain bushing. The second method is by means of a length of conduit large enough to carry the wires, each one incased in loom for the entire length and projecting out at the end of the conduit at least 3 in. Fig. 16 clearly illustrates the two constructions.

Conditions may be encountered where it will be found advantageous to take the motor supply from the same panel box that the lights are supplied from. If the feeders are large enough and the maximum current does not exceed 30 amp., the machine may be connected direct to a spare lighting circuit in the box, if such a circuit exists. If there is not a spare circuit in the box or the maximum current exceeds 30 amp., where the feeder to the panel box is large enough to supply the motor current in addition to the lights, the motor circuit may be tapped to the feeder in the gutter between the panel board and the box, as shown in Figs. 17 and 18, and run to a separate fuse box alongside of the panel board. Where a surface cabinet is used, as in Fig. 17, the connection can be brought from the feeder to the motor fuses in solid or flexible conduits. The wires can be run in moldings or in openwork if the holes entering the cabinet are properly bushed. Where flush panel boxes are encountered, a portion of the wall may be cut away and the pipe bent so it will enter the box. If a wooden box lined with steel is used, the work may be done on knobs or in molding; the wire can be carried into the panel box through loom, as in Fig. 18. This could also be done in case the panel box is made of metal, except that the sides of the box cannot be cut away, the wire entering by hole, properly bushed with porcelain, in the side of the box.




FIGS. 17 AND 18. METHODS OF TAKING A CIRCUIT FROM FEEDER IN PANEL BOX

**"Fractional Distillation"** is the term employed to describe a process of distillation of a mixture containing two or more substances which it is desired to recover. If, for instance, a mixture of glycerin, water, alcohol, chloroform and ether were distilled, the ether, having the lowest boiling point, would evaporate first, then the chloroform, next the alcohol and lastly the water, while the glycerin would remain in the still. By changing the receiver at the right moment, these substances might therefore be collected separately as byproducts.

# Pounds of Air per Pound of Coal

By Victor J. Azbe

*SYNOPSIS—A somewhat novel or perhaps revolutionary suggestion is made that the time-honored expression "pounds of air required to burn a pound of coal" be discarded and in its place "pounds of air per 10,000 B.t.u. substituted.*

A confusing expression in steam engineering and one badly requiring reformation, for at the present it is almost valueless, is "pounds of air per pound of coal," but if changed so that it could be employed for comparison in all cases it would become of great value.

TABLE 1. AIR REQUIRED FOR DIFFERENT FUELS

| Fuel | Air Theoretically Required per Lb. of Coal | Air Theoretically Required per 10,000 B.t.u., Generated |
|---|---|---|
| Illinois bituminous, poor quality | 7.0 | 7.6 |
| Illinois bituminous, good quality | 9.4 | 7.55 |
| Anthracite, average | 10.2 | 7.65 |
| Semibituminous, Pocahontas | 11.2 | 7.5 |
| Liquid fuel | 14.24 | 7.04 |

It has been impressed on the engineer's mind that, theoretically, coal requires 12 lb. of air for its combustion and, in practice, 50 per cent. in excess of this, or 18 lb. These values are frequently used by teachers, writers of engineering articles and designers of various apparatus for the boiler plant. While it is an easily remembered approximate in round numbers, the "12 lb. of air per pound of coal" does not hold true, as can be seen in the first column in Table I, since the theoretical amount of air per pound of coal varies between 7 and a little over 11 pounds.

The formula, $11.52C + 34.56\left(H - \frac{O}{8}\right) + 4.32S$, for determining the amount of air theoretically required to burn a certain fuel shows that the air required depends on the amount of combustible, and supposing the fuel to be pure carbon, it would require only 11.62 lb. of air per pound, while coal having a large percentage of ash, moisture and oxygen consequently requires a great deal less.

It is suggested, therefore, that the expression be changed to "pounds of air per 10,000 B.t.u." In the second column of Table I it will be seen that this expression would give much more definite information, having only slight variation due to the fact that hydrogen, carbon and sulphur require different weights of air to generate a certain amount of heat.

TABLE II. AIR REQUIRED FOR HYDROGEN, CARBON AND SULPHUR

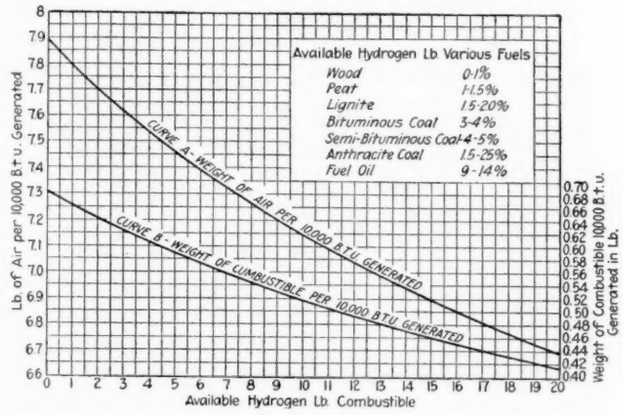
| | Air Theoretically Required per 10,000 B.t.u., Generated | |
|---|---|---|
| | Lb. | Per Cent. Compared with Carbon |
| Hydrogen | 5.574 | 72.7 |
| Carbon | 7.89 | 100.0 |
| Sulphur | 10.66 | 135.1 |

To explain the variation further, Table II was computed, from which it will be noticed that hydrogen requires the least and sulphur the most air to generate a certain amount of heat. Taking the air required for carbon as 100 per cent., hydrogen for the same amount of heat will require 72.7 per cent. and sulphur 135.1 per cent. as much air.

Curve *A* shows the weight of air required to generate 10,000 B.t.u. with fuels having different hydrogen content. In calculating this curve sulphur was disregarded, since its amount in a fuel is ordinarily so small that it will cause only a slight error. If one other factor (pounds of air per 10,000 B.t.u.) is determined, that particular factor can always be used with the same kind of fuel. For example, in a certain territory bituminous coal has 3 per cent. available hydrogen, and the curve shows that the required amount of air to obtain 10,000 B.t.u. theoretically will be 7.6 lb. Therefore this factor (7.6) can be always used in that territory, since any change will be chiefly in the amount of ash and moisture, and the available hydrogen will remain about the same.

The proposed mode of expression will simplify calculations that are frequently made by the engineers as follows:

A. A bituminous coal contains 3 per cent. available hydrogen. What weight of air is used when there is 7 per cent. $CO_2$ in flue gases?


Available Hydrogen Lb Various Fuels
Wood 0-1%
Peat 1-1.5%
Lignite 1.5-20%
Bituminous Coal 3-4%
Semi-Bituminous Coal 4-5%
Anthracite Coal 1.5-25%
Fuel Oil 9-14%
CURVE A-WEIGHT OF AIR PER 10,000 B.T.U. GENERATED
CURVE B-WEIGHT OF COMBUSTIBLE PER 10,000 B.T.U. GENERATED
Lb. of Air per 10,000 B.t.u. Generated
Weight of Combustible 10000 B.t.u. Generated in Lb.
Available Hydrogen Lb. Combustible

THEORETICAL AIR AND COMBUSTIBLE PER 10,000 B.T.U.

With 3 per cent. *H* the factor is 7.6 and

$$\frac{(F \times CO_2\ theor.)}{CO_2} = \frac{7.6 \times 19.5}{7} = 21.45\ lb.$$

B. What is the fuel loss with the same fuel with 7 per cent. $CO_2$, 600 deg. F. flue-gas temperature and 80 deg. boiler-room temperature?

$$L = \frac{W \times Sp.H. \times (T_2 - T_1)}{10{,}000}$$

$$= \frac{(21.45 + 0.62) \times 0.24 \times (600 - 80)}{10{,}000} = 27.5\ per\ cent.$$

C. What weight of air is theoretically required per pound of this fuel supposing one pound has 12,000 B.t.u.?

$$\frac{F \times B.t.u.}{10{,}000} = \frac{7.6 \times 12{,}000}{10{,}000} = 9.12\ lb.$$

D. What weight of air is used per pound of the fuel containing 12,000 B.t.u. per pound when there is 10 per cent. $CO_2$ in the flue gas?

$$\frac{F \times B.t.u. \times (CO_2\ theor.)}{CO_2 \times 10{,}000} = \frac{7.6 \times 12{,}000 \times 19.5}{10 \times 10{,}000}$$

$$= 17.78$$

In the equations given,

$F$ = Pounds of air per 10,000, B.t.u. obtained from Curve *A*;

10,000 = 10,000 B.t.u., the proposed basis for all calculations;

$W$ = Weight of air plus weight of combustible (weight of combustible can be obtained from Curve *B*);

$CO_2$ *theor.* = Theoretical maximum $CO_2$ obtainable[1];

$CO_2$ = Percentage of $CO_2$ found in flue gas;

$Sp.H$ = Specific heat at constant pressure;

$T_2 - T_1$ = Temperature difference between boiler room and boiler uptake.

Ordinarily, to make the foregoing calculations it would be necessary to know the percentage of all or most of the following constituents of the coal: Carbon, hydrogen, oxygen, sulphur, moisture, ash and the B.t.u. value; while with the proposed method, after the factor is once determined, the B.t.u. value is all that is necessary to obtain the fuel loss under different conditions.

It would appear at first that to determine the available hydrogen would be quite a difficult matter, but since the Government coal analysis gives the hydrogen and the oxygen contents of most fuels, all that is necessary is to divide the oxygen percentage by 8 and subtract the amount obtained from total hydrogen. The result will be the available hydrogen, as shown by the following formula:

$$H - \left(\frac{O}{8}\right) = \textit{available hydrogen}$$

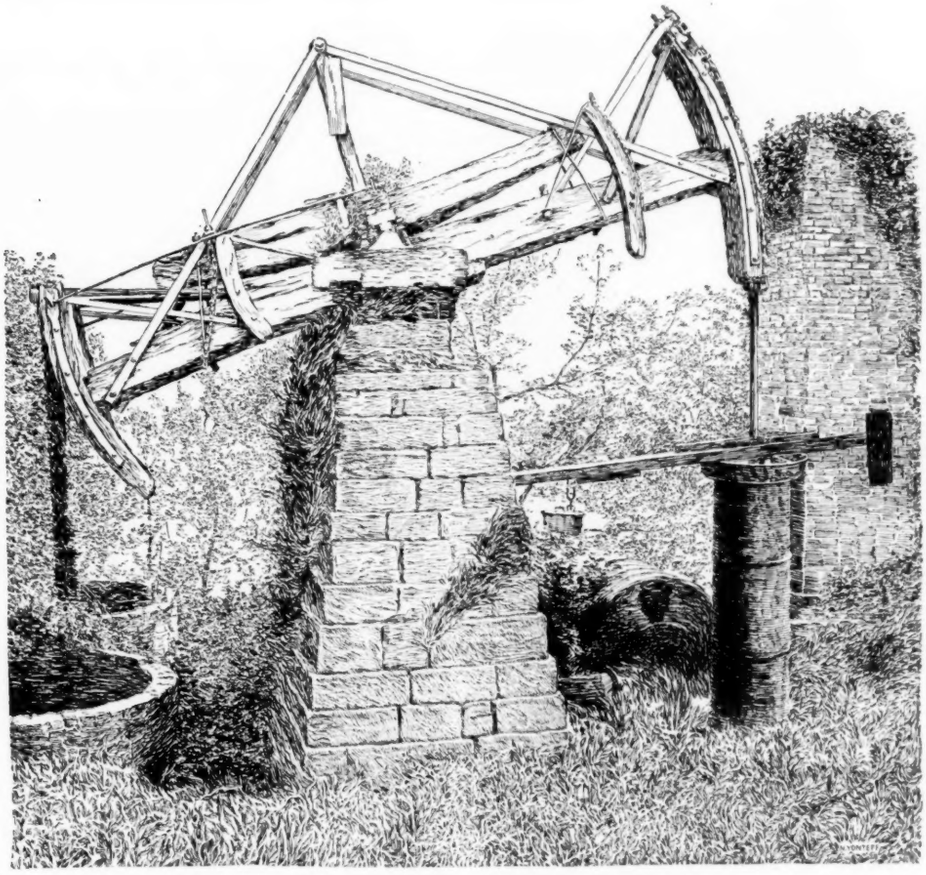
[1]In "Power," Apr. 18, 1916, p. 543, the author has a curve showing the $CO_2$ available with fuels of varying hydrogen.

It can be seen that the new method is much more simple and if everybody accepts this mode of expression, comparison of results will be greatly simplified, even if two altogether different fuels are used.

The usefulness of the suggested base of 10,000 B.t.u. would be increased still more if adopted in the boiler-test code and instead of saying "pounds of water evaporated per pound of coal" say, "pounds of water evaporated per 10,000 B.t.u.," which will at once convey to one's mind the approximate efficiency of the boiler and furnace; while under the present expression it does not mean anything without an exact knowledge of the quality of coal, as the efficiency of the boiler evaporating 6 lb. of water per pound of fuel might be greater than that of the boiler evaporating 8 pounds.

## Atmospheric Engine at Ashton-under-Lyne

The illustration is from a photograph supplied by Maurice Lees, Park Bridge, Ashton-under-Lyne, and published in *The Engineer* of London. It represents another interesting old engineering relic which is still to be seen at Fairbottom, near Ashton-under-Lyne, although its active career terminated nearly 100 years ago. It is another of the old Newcomen pumping engines, which found extensive application for pumping operations at collieries. It has often been illustrated. The steam side of the engine comprises a cylinder 26 or 28 in. diameter, with a stroke of 6 ft. The beam, as will be seen, is of wood braced with iron and has segmental ends to which the piston rod and pumps are attached by chains. It was formerly used for pumping water from the Cannel mine, 70 or 80 yards deep, in which it was assisted by a water-wheel, since removed. The steam was generated in a wagon boiler, now standing alongside, and the coal was brought from a pit some distance away. It is reported that the piston was kept steam-tight by pouring on top of it a solution of horse manure and water.



OLD NEWCOMEN PUMPING ENGINE

**The Combined Tensile Strength of Materials** is sometimes greater than that of either one alone. A compound consisting of 5 parts of gold and 1 of copper has a tensile strength of more than double that of gold or copper alone. Brass, composed of copper and zinc, has a tensile strength more than double that of the copper and nearly 20 times as great as that of the zinc alone, and a mixture of 8 parts of lead and 1 of zinc has a tensile strength nearly double that of the zinc and nearly five times that of lead alone.

# On the Job with the Refrigerating Troubleman

By E. W. Miller

*SYNOPSIS—A valve disk in the suction line comes loose from its stem and throttles the gas, giving serious difficulty to the engineer in getting sufficient capacity from the compressor. Weak springs holding down a false head in a compressor cause annoying knocks. Defective gages and air and foul gases in the condenser are troubles found in another plant.*

The owners of a small packing house had considerable trouble with their engineers, each of whom remained on the job no longer than three months. By the time the plant was two years old it was more or less in need of repairs in places. One day the engineer, who by the way had been on the job only a few days, was surprised to find that the back pressure on one of the ammonia compressors had dropped from 25 to about 10 lb. Another smaller machine running on the low-temperature rooms went along well. At the same time the machine on which the pressure had dropped began to freeze, and the temperatures in the coolers began to increase. The engineer tried everything he could think of to remedy the trouble, but to no avail, as the temperature kept gradually going up every day. The only thing that allowed the killing operations to continue was that the weather was cool enough to require but a small amount of refrigeration in the establishment.

### The Troubleman Arrives

The engineer got his "passports," and a new man was hired. He had no better success, and the owners in desperation finally called on the company that installed the machines to see if it could locate the trouble. The manufacturer's troubleman, after looking the plant over, decided to check the gages. When he removed the suction gage of the troublesome machine, he found the hand was loose on the stem; but when it was repaired and put back on the machine, it still showed only about 10 lb. The troubleman claimed that this defective gage was the only thing wrong with the whole system, that the gage had never indicated the correct pressure and that this was the reason for the high back pressure previous to the trouble. Not being able to find anything wrong, he finally went away, informing the owners that the machine was too small for the work and that they would have to add a new one. What no one could understand, however, was that the machine had done the work nicely before and the load at this time was not anywhere near the maximum previously carried.

I dropped in to visit the engineer a few days after this, and he related his troubles. Becoming interested, I offered my services, which were gladly accepted. We made a trip around the plant, and the one thing that struck my attention was the small opening given the expansion valves, even those on some very long coils. All the rooms carried by this machine were above 35 deg., and accordingly the expansion valves on some of the coils should have been open at least half a turn, as the valves were only half-inch and some of the coils were over 3000 ft. long.

The engineer informed me that he had to "pinch back" on the expansion valves from the day that the back pressure had gone down. This sounded unreasonable. Normally if the back pressure goes down and the room temperatures remain the same or go up, as they did in this case, the expansion valves can be opened a little more; for when the pressure goes down, the ammonia drops in temperature, which increases the temperature difference between the boiling ammonia and the room, and consequently the coils will evaporate more ammonia. Also, if the back pressure goes down with the room temperatures remaining the same, the machine always warms up until the expansion valves are opened more. In this case the machine froze, while the cooler temperatures went up.

### Pressure High in Evaporating Coils

Now it was plain from the amount the expansion valves were opened that the coils were not evaporating the quantity of ammonia they should with the suction pressure carried. As the coils were comparatively clean, there could be only two reasons for this: The coils might be loaded with oil and so were incapable of doing their work; in this case, however, the change would have been gradual instead of happening suddenly, as it did. Or, what looked to me like the most reasonable solution, the pressure in the coils was too high, in which case the coils would not evaporate sufficient ammonia, as the temperature difference between the rooms and the ammonia would be decreased. By the same reasoning, if the pressure in the coils was excessive, there must be some place in the suction line where the gas was throttled to bring it down to the low suction pressure.

We went back to the engine room, removed the suction gage and connected it to one of the expansion coils. To our surprise it registered over 30 lb. As all the coils were acting the same, I concluded that the trouble must be somewhere in the suction line. We started back along the suction line, thinking that we might hear where the throttling was taking place. When we got back as far as the engine room, we could hear a hissing sound, like steam passing through a partly closed valve. Further investigation located the sound in a stop valve in the suction line some distance from the compressor.

### Defective Stop Valve Throttles Gas

We immediately got busy, pumped down the system and opened up the valve. The solution of the trouble was quite simple. The valve was of the angle type and had been placed in the line with the stem horizontal, in which position, in this line, the flow was against the disk. The disk had rattled loose from the stem and had gradually worked up to the seat, thus throttling the gas. I advised the engineer to reverse the valve at the first opportunity.

A 250-ton vertical single-acting twin-cylinder compressor had been thoroughly overhauled. After it had been put back into service for a few days, it developed a slamming knock, first in one cylinder and then in both, though when the cylinders were opened and everything checked they were found to be tight and solid.

When the machine was started again, it knocked as much as ever. Thinking the knock might be caused by too little clearance, which had been adjusted to $\frac{1}{32}$ in., the clearance was increased, first to $\frac{1}{16}$ and then to $\frac{1}{8}$ in. without results. The suction valves are located in the piston, and their weight is balanced with a spring that tends to open the valve, which is practically opened by its own inertia as the piston starts on the return stroke and requires little pressure to open it. Thinking that this valve opened so freely as to come up far enough to strike the head, we removed the spring from the valve, but without the desired results.

### Springs Too Weak in False Head

It was peculiar that the knock did not seem to occur just when the crank passed the center, but after it had moved some distance past the center. The machine was equipped with false heads; and when these were being replaced, the oiler suggested that the springs holding down the false heads might be too weak. At this suggestion, enough washers $\frac{1}{2}$ in. thick were made to go under all the springs of one head. When the machine was brought up to full speed, the side that had been supplied with the washers ran noiselessly, while the other knocked as badly as ever. When washers had been put under the springs of this side in the same manner, the knock disappeared.

Responding to a hurry call from an engineer friend, I found that the chief trouble was that the condenser pressure was unusually high, about 225 lb. The relief valve was set at 235 lb. I suspected that air and foul gas had accumulated in the condenser, and I asked the engineer if he had purged the air out of the condenser lately. He admitted that he had not done this since the plant was started and that he really did not know how to go about it. It was the first place, by the way, where he had been in charge, although he had worked around refrigerating plants quite a little before he took charge of this one.

We spent nearly all the afternoon getting the air out of the condenser, but the pressure had dropped to only 205 lb. I was unable to account for this, as I was certain that all the air was out and that every coil was working, as was evidenced by the even temperature of the whole condenser. I was also satisfied that the condenser was of more than ample capacity for the work it was doing. The condenser water was taken from a deep well at a temperature of 58 deg., and the condenser was flooded with it. On inquiry, the engineer informed me that the condenser pressure had been gradually going up all winter; but as he only ran the machine very slowly, it had not bothered him any.

### Serious Rise in Room Temperature

And this was not the whole trouble. Although the weather was not yet hot by any means, he was having trouble in keeping the temperatures down. In previous years, the superintendent informed me, there had not been the least trouble in keeping the temperatures down in the hottest weather. He went through the rooms, and I was surprised to find that he was practically carrying only two or three low-temperature rooms; the rest were nearly shut off. The suction pressure, as indicated by the gage, was about 15 lb., which considering the circumstances, was very good. The suction side of the machine was nicely frosted, and the discharge just about the right temperature. I was unable to see anything wrong anywhere and left the plant.

In about a week another warm spell came along, and the engineer called up and informed me that the condenser pressure had gone up to 230 lb. and that he could not keep the rooms down to the proper temperature. I found him trying to draw up on a leaky joint; but it got worse, so we decided to pump out and put in a new gasket.

The leak was in the discharge line. The line pumped down to about 50 lb. in a short time; after that we pumped for about an hour, and it hardly moved a pound. I began to suspect that the condenser pressure gage was not telling the truth. To satisfy myself, I removed it and then opened the valve in the gage line a little to see if there was any pressure on the line. As I had suspected, there was a strong vacuum on it. The gage, after it was removed, remained at 60 lb. The condenser pressure, instead of being 230 lb., had been about 170, which was not so bad. I later determined that there was a variation of 5 lb. from zero to 150 lb. between the two gages, but this was close enough for practical purposes.

### Suction Gage Out of Order

The men were not done with the joint yet, so I decided to have a look at the suction gage. When I removed it from the connection, it remained at 20 lb. To test it, I connected a tee to a connection on the condenser pump. On the branch of the tee I connected a 100-ft. length of garden hose, and on the other end of the run I connected the gage. The hand on the gage was then set back to zero. I then figured out the height of a column of water that would give a pressure of approximately 25 lb. and elevated the end of the garden hose to this height. Then the water was slowly turned into the hose until it escaped from the top. The gage showed about a pound higher than I had figured, but this was close enough.

As soon as we got started, I went around with the engineer and set the expansion valves about where I thought they ought to be. When we got back to the engine room, we found the suction pressure had gone up to 18 lb. As none of the rooms were carried below 10 deg., this was just about right for rooms that were similarly piped. Next, we went after the condenser and purged the air out of it again. When we got through, the condenser pressure had gone down to 135 lb. An explanation of the trouble was now quite simple. The excessive condenser pressure in part explains itself. Due to the defective suction gage and the engineer's trying to maintain a certain suction pressure, the system had been running on a vacuum and for this reason had run the stuffing-boxes too loose. The machine was of the single-acting type, so there was no pressure on the packing. Consequently, the air had leaked in around the packing, and this had run the condenser pressure up as it had accumulated in the condenser. To maintain the low suction pressure, the engineer was obliged to nearly shut off the greater part of the coils, and this was the reason he was unable to keep the temperatures down.

⌘

**A Cement for Patching Cast Iron** may be made of 16 oz. of finely pulverized cast-iron borings, 2 oz. sal ammoniac, 1 oz. sulphur. Mix well and keep dry. To use, take one part of the mixture to 10 parts cast-iron borings or filings and add enough water to make a stiff paste and calk it into the crack or hole to be repaired and let it set for 24 hours.

# The Design of Indirect Heaters

By Charles L. Hubbard

*SYNOPSIS—A general description of the usual types of indirect heaters, showing how the air is mixed to get the desired temperature and also giving pointers on means of support and piping to attain the best results.*

The term "indirect heater," as used in the present case, covers all forms of steam and hot-water radiators, or heating stacks, which are placed outside of the room to be warmed. Radiators of this type are located in the supply ducts leading to the rooms, and their heat is conveyed to the point where it is required by means of air currents, the temperature of which is raised somewhat above the normal temperature of the room, according to outside conditions. The air circulation may be either natural or artificial, from a fan, and may be taken from within the building or from out-of-doors, according to the special requirements in any particular case. Heaters of this kind are used, in one form or another, to a considerable extent in large buildings, and data regarding their design and arrangement should be of value to both the designing and operating engineer.

### Ducts for Recirculating Air

Rotation or re-heaters take air from inside the building and are in reality simply concealed direct heaters. They are often used in the entrance vestibules of stores, halls, office buildings, etc., where limited floor space or the finish of the room prohibits the use of direct radiators. Two typical forms are shown in Figs. 1 and 2. The first of these is the one commonly used in a vestibule, the air being taken down through one register, passing through the heater and upward through the supply register at the other side, as indicated by the arrows. This makes a symmetrical arrangement for a small room and keeps the air in motion. For larger entrances or corridors one downtake register may be made to supply two or more heaters and outlet registers located at different points, as shown in Fig. 2. This is a very compact arrangement and may be used in any room in place of a direct radiator where it is desired to avoid the use of the latter type. Heaters of this form, made up of 8-in. pin radiator sections, have an efficiency of about 1.8 B.t.u. per hour. per sq.ft. of surface per degree difference in temperature between the steam or water in the radiator and the *average* temperature of the air. Steam at 2 lb. gage pressure has a temperature of 220 deg., and the final temperature of the air delivered may be taken as about 100 deg. If the air is delivered to the heater at a temperature of 60 deg. the average temperature will be $(60 + 100) \div 2 = 80$ deg., giving a difference between the air and radiator of $220 - 80 = 140$ deg., or an efficiency of $140 \times 1.8 = 252$ B.t.u. per hr. per sq.ft of radiator. Having determined the probable heat loss from the room per hour, the square feet of radiation required is found by dividing this quantity by 252, or in round numbers 250.

The term indirect-gravity heaters is commonly applied to heating stacks taking their air supply from out-of-doors. Typical arrangements for this type of heaters, stacks and mixing dampers are shown in Figs. 3 and 4. In Fig. 3 the warm air will pass up at the left marked *A* and the cool air at *B* on the right-hand side. If the air is delivered to a room at the left of the flue, through a wall register, there will be a good mixture of the hot and cool currents. The cooler air, being at the back of the flue, will enter through the top of the register and, being heavier, will tend to fall. The hot air, entering through the bottom of the register at the same time, tends to rise, producing a good mixture, while if this same flue discharged to the right, the cool air would pass through the bottom of the register and tend to fall without mixing with the warm air, resulting in uncomfortable drafts upon those sitting near. In the latter case and if the heater must extend toward the left, on account of structural design, the casing and damper arrangement should be as shown in Fig. 4, in which the conditions necessary for a good mixture are found as previously explained. Fig. 3 is more compact and is used whenever it is possible to so locate the heater with reference to the flue.

### Supports for Indirect Heaters

Details for supporting indirect heaters and stacks under different conditions are shown in Figs. 5 to 8. The first of these is commonly used in buildings having a wooden floor construction. Rods having an eye or loop at one end and a screw at the other are screwed into the floor joists above, as shown, and pieces of pipe run through the loops for supporting the heater. A form adapted to fireproof construction is shown in Fig. 6 in which lengths of pipe are laid upon the flanges of the floor-beams above. The supporting rods are provided with hooks at each end, and iron bars are laid in the lower hooks for supporting the heater. When the ceiling is of such light construction that it will not support the weight of the stacks, they may be carried on pipe columns, as shown in Fig. 7. Two other methods of attaching hangers to overhead floor-beams are shown in Fig. 8 and require no further description. When reinforced-concrete floors are used, the stacks must be located beforehand and plates with tapped holes or screw-eyes set in place before the concrete is poured.

### Typical Pipe Connections to Heaters

The method of running the piping and making the connections with the stacks will depend somewhat upon local conditions. Fig. 9 shows a typical connection for a stack which is intermediate upon the line. The steam connection is taken from the top of the main to prevent pockets when shut off, and the return connection is carried directly into the return main below the water line. In case of a dry or overhead return, siphon loops should be inserted in the return connections of all stacks excepting those at the ends of the mains.

Typical connections for a stack at the end of the line are shown in Fig. 10. These are practically the same as in Fig. 9, excepting for the introduction of a drip pipe for draining the steam main, which operates equally well whether the stack is in use or shut off.

Computing the heat loss from a room is not within the scope of the present article, but the amount of heat to be supplied by the heater under different conditions will be

taken up. When an indirect heater is used simply for warming a room, without special reference to ventilation, it may be calculated as follows:

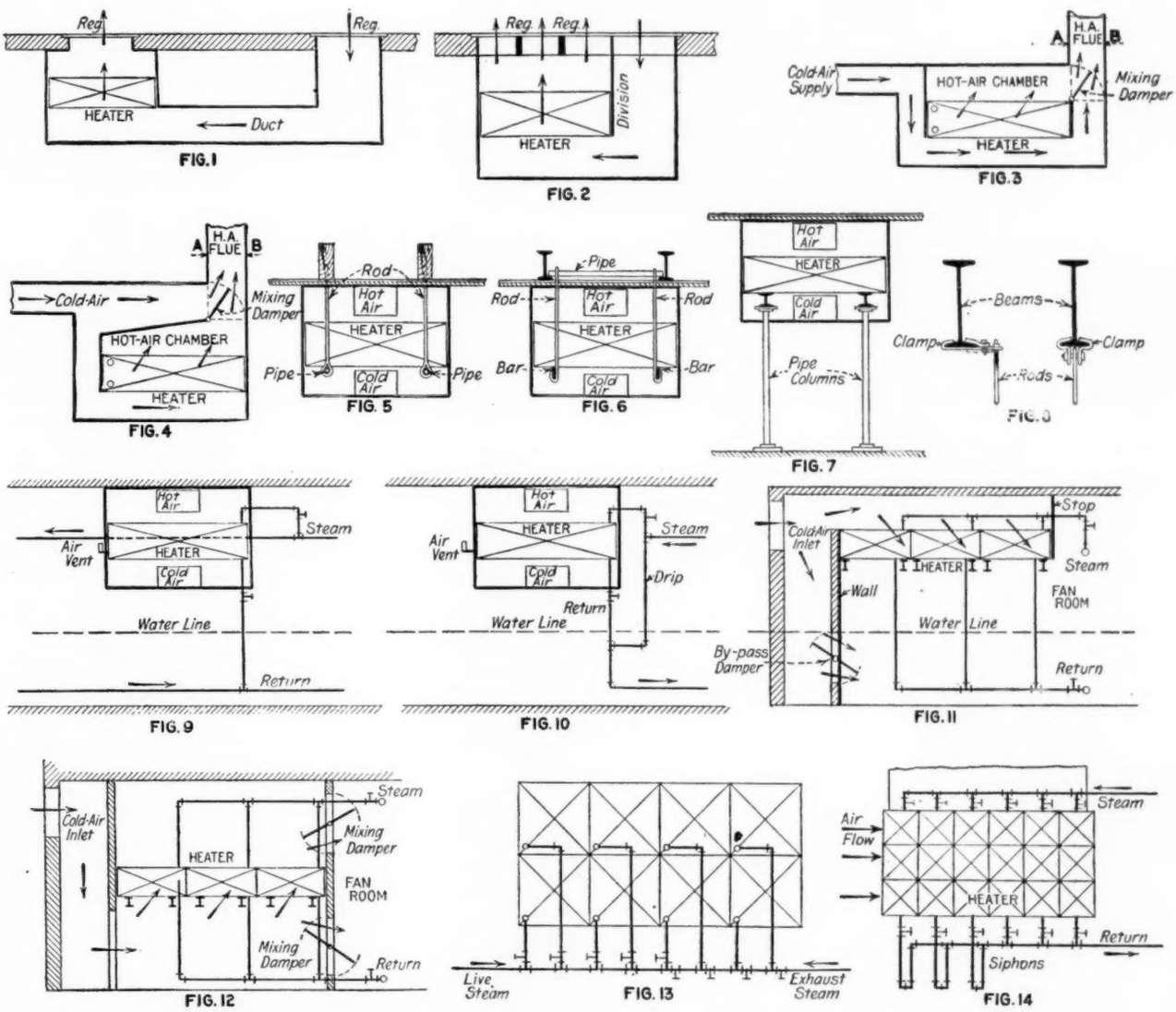
First ascertain the total heat loss per hour from the room by any standard method, then assume an air temperature of, say, 110 deg. for delivery to the room. Next determine what volume of air at this temperature will be required per hour, that by cooling from 110 to 70 deg. will give out an amount of heat equal to that lost during the same period. This is found by multiplying the total heat loss per hour by 55 and dividing by 40 (the drop in temperature). The result will be in cubic feet per hour. With an outside temperature of zero the problem now becomes, What quantity of heat will be required to raise this volume of air from 0 to 110 deg.? This is found by multiplying 110, the temperature of admission, by the cubic feet of air to be warmed, and dividing the result by 55 (being the degrees through which 1 B.t.u. will raise 1 cu.ft. of air).

Example: If the total heat loss from a room having a temperature of 70 deg. in zero weather is 20,000 B.t.u. per hr., how many cubic feet of air per hour must be supplied by an indirect heater to warm the room with hot air delivered at a temperature of 110 deg.?

Solution: Volume of air to be supplied = (20,000 × 55) ÷ 40 = 28,000 cu. ft. per hr. in round numbers. The heat required to warm this quantity of air from 0 to 110 deg. = (110 × 28,000) ÷ 55 = 56,000 B.t.u.

With average velocities of air flow (about 300 ft. per min.) 1 sq.ft. of indirect radiation will give off about 2.2 B.t.u. per sq.ft. of surface per hour per degree difference between the steam in the radiator and the average temperature of the air passing through it. Steam at 2 lb. gage has a temperature of 220 deg., and the average air temperature is (0 + 110) ÷ 2 = 55, making a difference of 220 — 55 = 165 deg., which gives the radiator an efficiency of 165 × 2.2 = 363 B.t.u. per sq.ft. per hr. Under these conditions, 56,000 ÷ 363 = 154 sq. ft. will be required. Allowing 1800 cu.ft. of air per person, for good ventilation, the room under consideration is suitably ventilated for 28,000 ÷ 1800 = 16 persons.

The general method of computation is practically the same for any other condition of air volume and tempera-




FIGS. 1 TO 14. GENERAL DESIGN OF INDIRECT HEATERS AND THE AIR COURSE THROUGH THEM

Figs. 1 and 2—Typical reheaters. Figs. 3 and 4—Arrangement of air mixing dampers. Figs. 5 to 8 inclusive—Hangers and supports for heaters. Figs. 9 to 14 inclusive—Supply and return piping arrangements for different conditions

ure, except for the radiator efficiency. The problem first worked out applies especially to offices, etc., where the number of occupants is comparatively small in relation to the cubic contents of the room.

Take the general type of a schoolroom accommodating 50 pupils and having a heat loss by transmission and leakage of 40,000 B.t.u. per hr. in zero weather. The air supply should be based upon the number of occupants and a lower temperature assumed. Taking 40 cu.ft. of air per occupant, the total volume per hour = $50 \times 40 \times 60 =$ 120,000 cu.ft. To heat from 0 to 70 deg. = $(120{,}000 \times 70) \div 55 =$ 156,000 B.t.u., in round numbers, making the total heat per hour 40,000 + 156,000 = 196,000 B.t.u. The temperature of the air as delivered, to contain this amount of heat, must be $(40{,}000 \times 55) \div 120{,}000 + 70 = 89$ deg. That is, the temperature of the air delivered to the room is found by multiplying the total heat loss per hour by 55 and dividing by the cubic feet or air supplied during that time and adding this result to the normal room temperature, which is usually taken as 70 deg. Owing to the larger air volume in this case, the air will pass through the heater at a higher velocity, thus increasing the efficiency to some extent.

### Heat Given off per Foot of Surface

At a velocity of 400 ft. per min. about 2.6 B.t.u. will be given off per square foot of surface per hour per degree difference between the steam and the average air temperature. Taking the steam at 220 deg. as before and the average air at $(0 + 90) \div 2 = 45$, the difference will be $220 - 45 = 175$ deg., giving a radiator efficiency of $175 \times 2.6 = 455$, from which $196{,}000 \div 455 = 431$ sq.ft of surface is required. With this general data at hand, the required surface can be computed for almost any condition likely to occur.

For offices, dwellings, etc., where heating alone is the first requirement, the ordinary "pin" radiator, 6 to 7 in. in depth is commonly used. For schools, halls, churches, etc., where larger volumes of air are required for ventilating purposes, the so-called "school-pin" radiator, from 10 to 12 in. depth with extra wide air spaces, is to be preferred.

After determining the size of stack and form of section, the best method of support with the aid of Figs. 5 to 8 is to be decided.

The term main heaters includes all heaters placed close to a fan and used for hot-blast heating or ventilation. A typical layout of heaters is shown in Figs. 11 and 12. The passage of the air through the heater is indicated by the arrows, and approximate temperature regulation is secured by separately valved sections, while close regulation is obtained by a bypass, or mixing damper, in the wall between the cold and hot-air chambers, shown at the left. In the second arrangement (Fig. 12) the cold air is brought in from below instead of from above. Double mixing dampers are connected by levers or links, so arranged that the lower one opens as the upper one closes, and vice versa. With heaters of considerable length two or more pairs of smaller dampers should be used. The best results are obtained by a pneumatic control system operated from a thermostat in the duct beyond the fan.

Typical methods of making the supply and return connections are also shown. A diagram of pipe connections for live and exhaust steam is shown in Fig. 13. In this arrangement the sections at the left can be supplied with live steam only, while those at the right may take either live or exhaust steam, as desired, by a manipulation of the valves, determined by the amount of surface required to condense the exhaust, which will of course vary with the outside temperature.

An end view of a standard wrought-iron pipe heater is shown in Fig. 14 and illustrates the precautions necessary in making the return connections so that there will be no backing of condensation from one section into another. When in use, the air which strikes the outer sections (at the left in Fig. 14) is much colder than that which reaches the inner sections. This results in a more rapid rate of condensation and a slightly lower pressure in these sections, which is likely to allow them to gradually fill with water from the other return connections, and in cold weather it may freeze and crack the headers. This condition can be prevented by placing water seals in the return connections from two or three of the outer sections, as shown in Fig. 14, to balance any inequality of pressure.

### Measurement of Heating Surface

The general methods of computing the heating surface for a main heater are much the same as already described for a gravity heater, although the conditions to be met are somewhat different. There are three principal conditions for which main heaters are designed, as follows: First, those used for ventilation only, where the air is raised from outside temperature to that of the room, usually from 0 to 70 deg. for maximum conditions; second, where the building is both ventilated and heated by the air passing through a main heater and is therefore raised from outside temperature sufficiently above that of the room to offset the heat lost, the maximum range in this case being from 0 to 130 or 140 deg.; third, where the air is recirculated within the building, being returned to the fan at about 60 deg. and delivered again to the room at a maximum temperature of about 140 deg. Sometimes the last two methods are combined and a portion of the air taken is from outside and a portion returned from the building.

### Computation of Pipe Surface

The computations which follow are for the standard form of wrought-iron pipe heater, made up of 1-in. pipe. When cast-iron sections of the "pin" type are used, each 8-in. section may be considered approximately the equivalent of four rows of pipe when determining the depth of heater for a given final air temperature. In designing heaters of this type it is not only necessary to compute the surface, but also the depth of heater (rows of 1-in. pipe) to obtain the required final temperature. The surface for a given heat supply depends upon the efficiency of the heater B.t.u. per sq.ft. per hr.), and this, in turn, upon the difference in temperature between the steam and air, the velocity of air flow and the depth of heater, upon which depends the final temperature. The first step in any case is to determine the quantity of heat to be supplied, which, in the case of ventilation only, is found by multiplying the volume of air in cubic feet by the rise in temperature and dividing the result by 55. For 1 cu.ft. of air and a rise from 0 to 70 deg., this will be $(1 \times 70) \div 55 = 1.3$. That is, the cubic feet of air multiplied by 1.3 will give the B.t.u. necessary to raise its temperature 70 degrees.

For steam pressures of 2 to 5 lb. gage and air velocities, through the heater, of 800 to 1000 ft. per min., Table I may be used in determining the rows of 1-in. pipe, or its equivalent, for different final temperatures, assuming the air to enter the heater at zero. The efficiency depends upon the depth of the heater, the air velocity and the relative temperatures of the steam and air. Table II gives the approximate efficiencies for the same conditions assumed for Table I (pressure 2 to 5 lb., velocity 800 to 1000 ft. per min.). From these tables it is evident that for raising the air from 0 to 70 deg. the heater must be 8 pipes deep and will have an efficiency of 1900 B.t.u.

TABLE I

| Rows of 1-In. Pipe | Final Air Temperature (from 0 Deg.) |
|---|---|
| 8 | 70 deg. |
| 10 | 80 deg. |
| 12 | 90 deg. |
| 14 | 100 deg. |
| 16 | 110 deg. |
| 18 | 120 deg. |
| 20 | 130 deg. |

TABLE II

| Rows of 1-In. Pipe | B.t.u. Given Off per Sq.Ft. of Surface per Hr. (Entering Air 0 Deg.) |
|---|---|
| 8 | 1,900 |
| 10 | 1,800 |
| 12 | 1,700 |
| 14 | 1,650 |
| 16 | 1,600 |
| 18 | 1,550 |
| 20 | 1,500 |

Example: What depth and size of heater will be required to raise the temperature of 30,000 cu.ft. of air per minute from zero to 70 degrees.

Solution: $30{,}000 \times 60 \times 1.3 = 2{,}340{,}000$ B.t.u. per hour.

Table I shows that the heater must be 8 pipes deep for this final temperature, and Table II that the efficiency is 1900 B.t.u. for this depth of heater. Hence, $2{,}340{,}000 \div 1900 = 1232$ sq.ft. is required.

When the air is to be raised to a higher temperature, proceed practically as for gravity heating. For example, suppose in the foregoing case the heat loss from the building is 600,000 B.t.u. per hr., what size and depth of heater will be required for both heating and ventilation? When the heat loss and the air supply are known, the excess temperature of the air supply above the normal room temperature is found by multiplying the heat loss in B.t.u. per hour by 55 and dividing by the cubic feet of air to be supplied (per hour). This result added to the normal room temperature will give the final temperature of the air supply.

### Application of the Rule to the Case

In this case the excess temperature will be $(600{,}000 \times 55) \div 2{,}340{,}000 = 15$ deg., calling for a final temperature of $70 + 15 = 85$ deg. The total heat to be supplied for both heating and ventilation in zero weather is $(2{,}340{,}000 \times 85) \div 55 = 3{,}600{,}000$ B.t.u. per hour.

Table I shows that 10 rows of pipe are required for a final temperature of 80 deg. and 12 rows for 90 deg.; so taking the latter to be on the side of safety and Table II showing the efficiency for a heater of this depth to be 1700 B.t.u., hence $3{,}600{,}000 \div 1700 = 2120$ sq.ft. of surface is required.

When a building is heated by a recirculation of air, by means of a fan and main heater, the air becomes simply a carrier of heat the same as steam or hot water. In cases of this kind the air is usually returned to the fan at a temperature of about 60 deg. and delivered at 140 deg. in the coldest weather. Here the air is cooled $140 - 60 = 80$ deg., and each cubic foot gives off $80 \times {}^{1}/_{55} = 1.45$ B.t.u.; hence, the B.t.u. lost per hour by transmission and leakage, divided by 1.45, will give the cubic feet of air to be circulated per hour.

To raise air from 60 to 140 deg. will require a heater 16 pipes deep, and the efficiency under these conditions will be about 1150 B.t.u. per sq.ft. per hour.

Taking the same example, where the heat loss is 600,000 B.t.u. per hr. it will require the circulation of $600{,}000 \div 1.45 = 414{,}000$ cu.ft. of air per hour and the heater should be 16 pipes deep and contain $600{,}000 \div 1150 = 522$ sq.ft. of heating surface.

## Boiler Test with Hog Fuel

An article was published on page 136 of the Jan. 30 issue describing the methods employed at the steam plant of the St. Paul & Tacoma Lumber Co.'s plant, Tacoma, Wash. At that time no test figures of the results obtained in burning refuse from the lumber mill were at hand. The test figures, now available, show in the accompanying table what the boiler plant is doing with shavings and hog fuel.

A TEST OF STIRLING BOILERS, TO DETERMINE EVAPORATIVE VALUE OF WOOD FUEL

| | | | Boiler No. 3 | | Boiler No. 4 |
|---|---|---|---|---|---|
| Kind of furnace, Dutch oven, length, ft | | | 6.5 | | 6.5 |
| Grate surface, sq.ft | | | 55.25 | | 62.82 |
| Water heating surface, sq.ft | | | 2,617 | | 2,878 |
| | February 20 and 21, 1917 | | | | |
| | Test No. 1 | Test No. 2 | Test No. 3 | Av. Nos. 1, 2, and 3 | Test No. 4 |
| Duration, hours | 8.0 | 4.0 | 2.5 | 14.5 | 2.5 |
| Kind of hog fuel | Shavings and Hog | Hog Only | Shavings Only | | Shavings and Hog |
| Av. steam pressure by gage, lb | 131 | 131 | 128 | 130 | 100 |
| Av. temp. feed water entering boiler, deg. F | 153 | 145 | 143 | 147 | 142 |
| Temp. of escaping gases, deg. F | 413 | 427 | 430 | 423 | 531 |
| Forced draft between damper and boiler, in | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Cubic ft. of fuel as fired | 3,000 | 1,055 | 857 | 4,912 | 717 |
| Aver. weight of fuel per cu.ft. as fired, lb | 15.32 | 18.37 | 14.64 | 16.11 | 12.75 |
| Percentage of moisture in fuel | 38.5 | 41.5 | 34.00 | 38.0 | 38.5 |
| Total weight of water fed to boiler, lb | 115,390 | 52,696 | 30,951 | 199,037 | 27,998 |
| Total units of evaporation, lb | 127,469 | 58,737 | 34,602 | 221,108 | 31,311 |
| Factor of evaporation | 1.104 | 1.115 | 1.120 | 1.108 | 1.120 |
| Cubic feet fuel consumed per hour | 375 | 264 | 343 | 339 | 287 |
| Cu.ft. fuel per sq.ft. grate surface, per hour | 3,176 | 2,236 | 2,905 | 2,871 | 2,431 |
| Water evaporated per hour, lb | 14,423 | 13,174 | 12,380 | 13,326 | 11,199 |
| Total equivalent evaporation from and at 212 deg. F., lb | 15,934 | 14,685 | 13,841 | 14,820 | 12,524 |
| Equivalent evaporation from and at 212 deg. per sq.ft. heating surface, lb | 2.90 | 2.67 | 2.52 | 2.70 | 4.36 |
| Boiler horsepower developed | 462 | 425 | 401 | 430 | 363 |
| Rated capacity per hr. from and at 212 deg. F | 19,000 | 19,000 | 19,000 | 19,000 | 9,050 |
| Rated boiler horsepower | 550 | 550 | 550 | 550 | 262 |
| Percentage of rated capacity developed | 84.0 | 77.2 | 73.0 | 78.2 | 138.8 |
| Water fed per cu.ft. as fired, lb | 38.46 | 50.00 | 36.10 | 40.05 | 39.00 |
| Equivalent evaporation from and at 212 deg. F., per cu.ft. fuel as fired, lb | 42.5 | 55.7 | 40.4 | 45.7 | 43.6 |
| Equivalent evaporation from and at 212 deg. F., per unit of 200 cu.ft., lb | 8,500 | 11,400 | 8,080 | 9,000 | 8,720 |
| Cu.ft. fuel per 1,000, equivalent evaporation from and at 212 deg. F | 23.5 | 17.9 | 24.8 | 21.9 | 22.9 |
| B.t.u. per cu.ft. wet | 84,352 | 96,497 | 81,882 | 87,555 | 84,352 |
| Boiler efficiency, per cent | 0.49 | 0.56 | 0.48 | 0.48 | 0.49 |
| B.t.u. per lb. wet | 5,506 | 5,253 | 5,593 | 5,451 | 5,506 |
| B.t.u. per lb. dry | 8,953 | 8,979 | 8,474 | 8,802 | 8,953 |

TEST MADE BY: R. L. Watts, mechanical superintendent;
E. H. Baker, efficiency engineer;
I. C. Dean, assistant efficiency engineer.

**Simple Alloy Steel** is alloy steel containing one alloying element, as, for example, simple nickel steel.

**To Make Pipe Covering Stick** to boiler heads, tanks or valves is sometimes difficult, but if the surface to be covered is given a coat of silicate of soda (liquid glass) and, while this is wet, dry asbestos is applied by the handful, it will stick, as the silicate will stick to the metal and hold enough asbestos to make an anchor for the following coats applied in the usual manner with a trowel. Another method is to wrap the part to be covered with 2-in. mesh chicken wire and plaster the asbestos over this foundation. The asbestos does not stick to the metal, but the wire holds it in place.

# Steam-Engine Troubles—Operation

By H. Hamkens

*SYNOPSIS—Locating trouble by the aid of the indicator. Forms of reducing motions are discussed. Measuring the clearance volume by water preparatory to comparing the actual expansion curve with the theoretical curve.*

Before the engineer takes charge of an engine, he should prepare himself for any emergency. Wrenches for the various sizes of nuts should be mounted on a board in a convenient place on the wall; on the same board should be eye-bolts for lifting the main-bearing cap, quarter-boxes and shells, for removing the back cylinder head, piston follower and junk ring, and for taking out the valves. If no spare parts have been furnished with the engine he should see that the following parts are ordered: One steam bonnet and one exhaust bonnet with a valve stem for each; an exhaust arm; a full set of catch plates and some springs if any are used on the valve gear; a few extra follower bolts and nuts; and extra sets of crosshead and crankpin brasses with some wedge bolts; also a packing ring for the piston. Sheet-rubber or copper gaskets for joints that may blow out should be kept in stock. There should be an assortment of good files, scrapers and chisels, and a workbench with a vise and a drawer in which to keep the small tools. Extra pipe fittings and some brass pipe should be provided for small repairs and changes of the oil piping. The builders should furnish detail drawings of all the moving parts with a chart or diagrammatic drawing showing the names and positions of the principal parts of the engine. This the engineer must have, so that no time may be lost owing to misunderstanding if the necessity arises to order quick repairs.

Every Corliss engine should be provided with indicator piping. The arrangement, Fig. 196, should show a long-radius elbow cock at each end and a three-way cock in the middle, the most convenient for everyday use, when it is more a question of correct valve setting and average load than of absolute accuracy. For a test two indicators should be used—one of them to be placed at each end of the cylinder with the shortest possible connections.

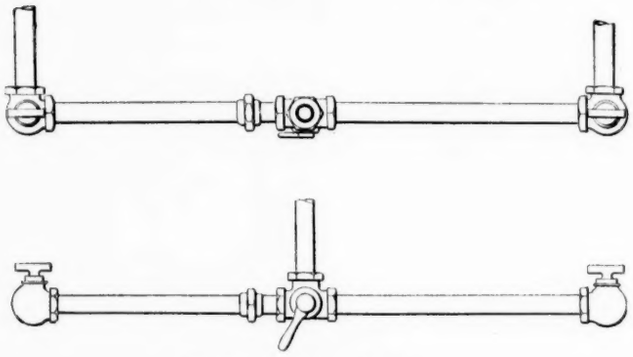


FIG. 196 Indicator Piping

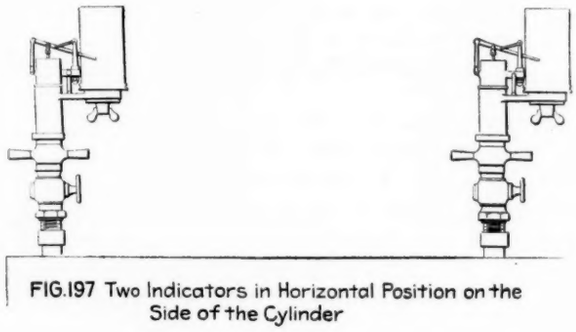


FIG. 197 Two Indicators in Horizontal Position on the Side of the Cylinder

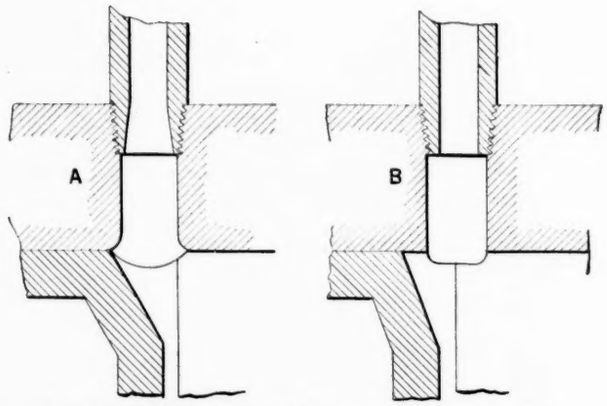



FIG. 198 Indicator Hole and Nipple in Side of Cylinde.

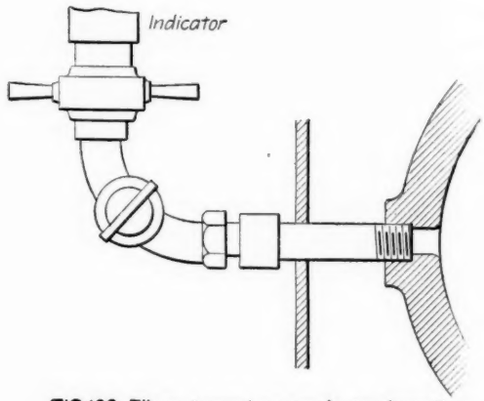



FIG. 199 Elbow turned upwards to place the Indicator in a Vertical Position

FIGS. 196 TO 199. INDICATOR CONNECTIONS AND CONNECTION DETAILS

The most direct way is to place the indicators in a horizontal position, with the straightway cocks screwed into the couplings on the short pieces of pipe, as shown in Fig. 197.

Access to the hole in the side of the cylinder must be free; the hole should have beveled or rounded edges, and the nipple should taper on the inside, as shown at *A*, Fig. 198. The piston must not overrun the indicator hole, preventing free access at the beginning of the stroke; neither should there be sharp edges in the cylinder or nipple, as shown at *B*, which will cause a drop in initial

pressure in the indicator. These minor details are often lost sight of in indicating an engine. If the horizontal position of the indicators is inconvenient, they may be placed vertically on long-radius elbows turned upward, as shown in Fig. 199 (in which position they are readily manipulated with only a trifling loss in pressure).

Before placing the indicators in position, all pipes, fittings and passages must be blown out to free them from grit, gummy oil or other foreign matter to prevent the instruments being fouled. In long indicator pipes the condensation is often a disturbing factor; the water must always be blown out before a card is taken, otherwise the diagrams will be unreliable. It is evident that, whatever arrangement is adopted, there is apt to be some inaccuracy, therefore the one that is likely to give the least error should be chosen.

An indicator is almost indispensable in an engine room. The medium-priced instruments with inside spring will give fairly good results for everyday use, either with permanent reducing motions furnished with the engine or with reducing motions driven by cords and attached to the indicator. For accurate tests the best instruments, with calibrated outside springs and electrical attachment for instantaneous operation, must be used; the reducing motions must be of the highest order, with the cords running in a straight line to the crosshead.

A simple reducing motion for temporary use may be made as shown in Fig. 200. A bracket made of a bar of flat steel is fastened to the top of the guide, with a wooden lever suspended from a bolt at the upper end. The connection to the crosshead is by means of a horizontal link, also made of a strip of wood, and a sector of the required size to give a motion of about 4 in. at the circumference is fastened to the lever at the pivot. On high-pressure cylinders the cord can usually be attached directly to the indicator, but on some low-pressure cylinders, on account of their width, a couple of carrying pulleys must be used. If there is no vibration to the bracket and if the bolts are well fitted with brass bushings in the lever and link, the arrangement will give good service. Of course it is not intended for permanent use and does not improve the appearance of an engine.

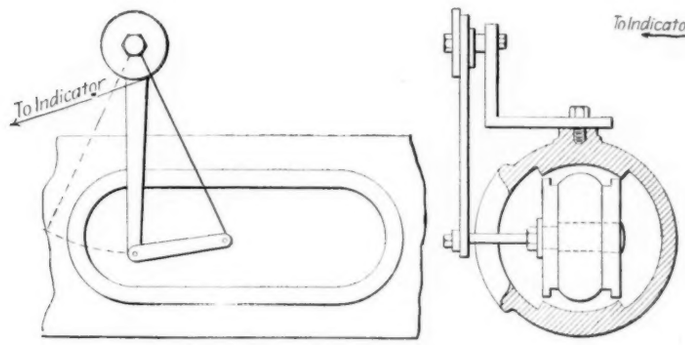



FIG. 200 Lever Reducing Motion

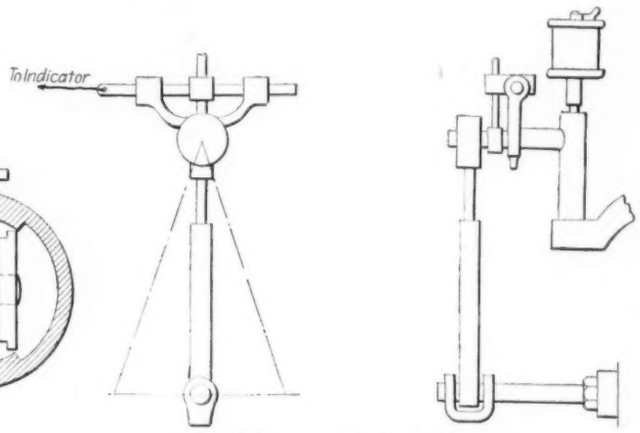



FIG. 201 Telescopic Reducing Motion

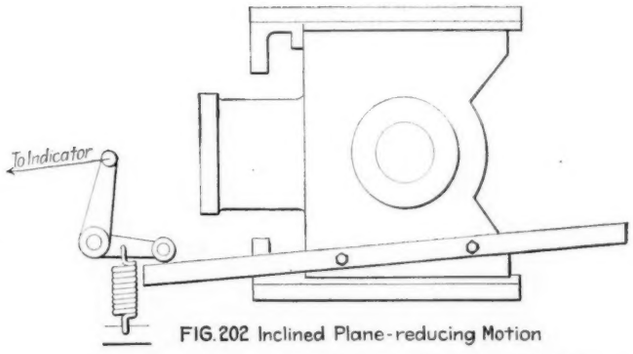



FIG. 202 Inclined Plane-reducing Motion

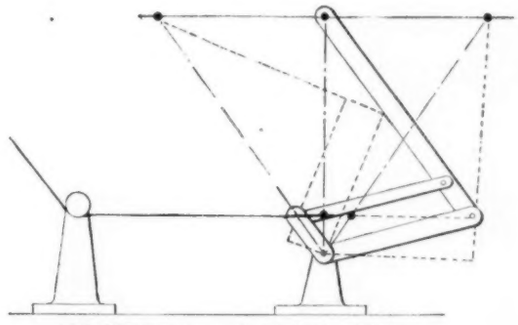


FIG. 203 Pantograph Reducing Motion

FIGS. 200 TO 203. VARIOUS FORMS OF REDUCING MOTIONS

Something of the same order for a permanent rig is shown in Fig. 201. This works on the telescopic principle and serves the double purpose of crosshead-pin oiler and reducing motion. Running all the time, the device soon begins to wear and loses its accuracy; besides, the telescopic oiler is liable to get clogged and leaky, which may be the cause of a hot pin.

A permanent reducing motion that can be engaged or disengaged at will is shown in Fig. 202. It consists of an inclined plane in the shape of a steel bar fastened to the crosshead; a two-arm lever with a roller on the horizontal arm running on the bar transmits the motion to the indicator. The device can be thrown in and out of gear by securing the lever in such a position that the roller does not touch the bar.

Fig. 203 represents a pantograph in its simplest form, with the fulcrum pivoted on a stand fastened to the floor. The cord is led over rollers to the indicator. The apparatus can be connected to the crosshead or disengaged only when the engine is stopped.

Reducing wheels attached to the indicator and driven by cords, as shown in Fig. 204, are largely used. There are three cords used—one from the crosshead to the large wheel, a second one from a small pulley to a spring case and the third from another pulley to the indicator drum. On account of the number of cords the device may become troublesome; if the cords run unevenly or ride, the indicator cards will be inaccurate.

A more reliable and easily operated apparatus is shown in Fig. 205. Only one cord is used between the crosshead and the spring case. The latter is provided with a clutch that enables the operator to stop the drum of the indicator at any time for removing and renewing the card without disturbing the cord to the crosshead. The paper drum can also be stopped by turning a thumb-piece on top of the drum. The reduction in stroke in this reducing motion is made by means of a worm and wormwheel, the latter forming the base of the drum. There are only a few parts in the mechanism, which materially reduces the chance of anything wearing out or getting out of order.

A new engine should be frequently indicated and samples of the diagrams calculated, analyzed and placed in a record book for reference. The diagrams should be about 4 in. long and not over 2 in. high, as this is the limit of the pencil mechanism. In measuring the height of the diagram from the atmospheric line with the same scale as marked on the spring, the initial pressure in the cylinder can be found; comparing this with the boiler pressure will show the drop between boiler and engine. The distance between the exhaust line and the atmospheric line shows the back pressure in the cylinder on the return stroke of the piston. Of course both the steam gage and the indicator spring may be incorrect. They may be compared as follows:

Place the indicator on a suitable pipe connection at the boiler, then raise steam and as it rises draw lines on a card by moving the drum by hand; when the gage registers 10 lb., 20 lb., etc., up to the working pressure, mark the pressures on the card, as shown in Fig. 206, and compare them with the scale. If there is any marked difference between the two, a test gage will have to be procured, attached to the boiler and the regular gage checked with it for the different pressures, as before; comparing the readings on the gages with the straight lines on the card and the scale will show what allowance should be made in determining the pressures on the diagrams taken from the engine.

The difference between boiler pressure and initial pressure in the cylinder should not exceed 5 lb., neither should the back pressure be more than 1 lb. above atmospheric, unless the exhaust steam is used for heating. In condensing engines the difference between the vacuum in the condenser and in the exhaust at the engine should not exceed 2 in. of mercury. Short and numerous pipe elbows or bends, long pipes or pipes of too small a diameter are often responsible for a reduction in pressure.

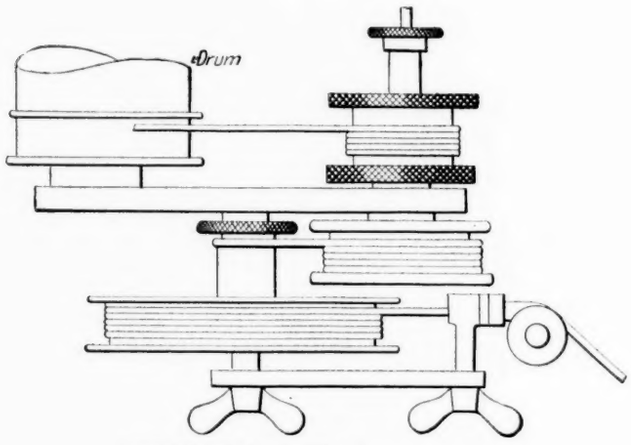



FIG. 204 Reducing Wheel

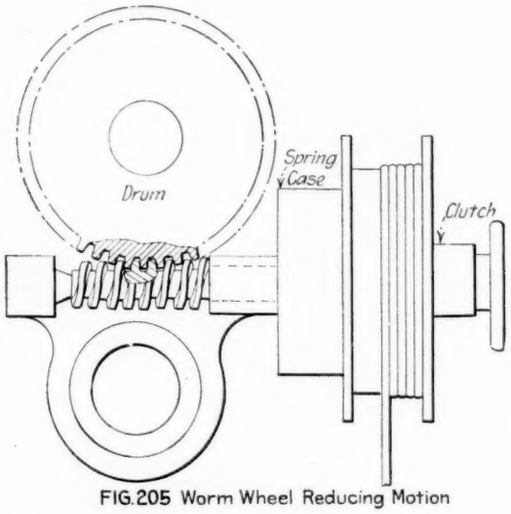



FIG. 205 Worm Wheel Reducing Motion

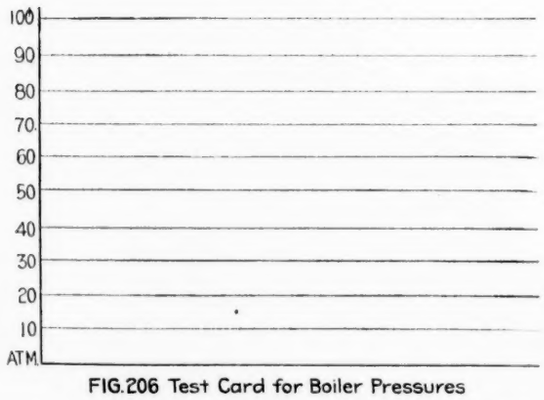



FIG. 206 Test Card for Boiler Pressures

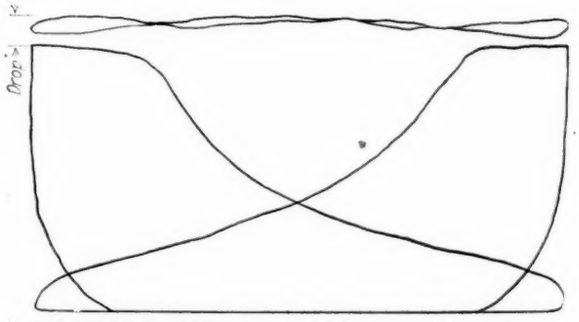



FIG. 207 Combined Diagrams of Cylinder and Steam Chest

FIGS. 204 TO 207. REDUCING WHEELS, INDICATOR SPRING TEST CARD AND COMBINED DIAGRAMS

A loss in pressure may also occur in the steam chest or in the valves and ports. This can be ascertained by attaching an indicator to the steam chest, taking cards from it and from the cylinder and combining the two, as shown in Fig. 207, in which the drop in pressure is indicated by the difference in height at both ends of the diagram. On well-designed engines the drop should not exceed 2 lb.

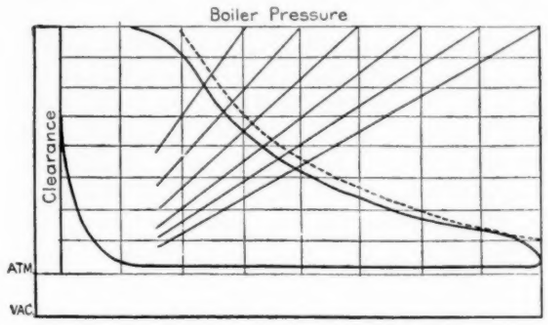



FIG. 208. CLEARANCE DIAGRAM

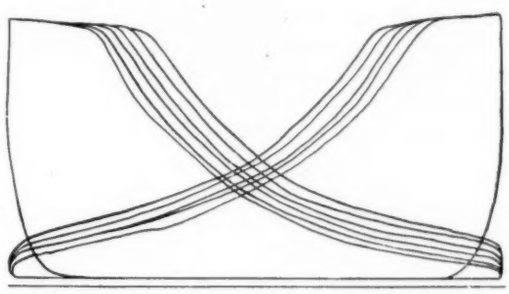


FIG. 209. SEVERAL DIAGRAMS ON ONE CARD

To make a comparison between the expansion curve of a diagram and the theoretical, or hyperbolic, curve, the clearance in the cylinder, ports and valves will have to be determined, either by figuring it from actual measurements or by measuring it with water. The latter method is the more correct one, provided there are no leaks in the piston or exhaust valves. The water may be poured in through the steam port with the steam valve removed until it stands level with the port. The piston should of course be at the end of the stroke and the corresponding exhaust valve closed. By using a graduated measure for filling the clearance space, the quantity of water in gallons or pints will be known; converting these into cubic inches and dividing by the piston displacement will give the percentage of clearance. With the clearance known, a line representing it and another line for the vacuum must be drawn on the diagram, as shown in Fig. 208, and taking the terminal pressure as the starting point, the isothermal expansion curve is plotted. Any considerable difference between the theoretical and the actual expansion curves of the diagram will indicate leaks in the piston or valves, which can be located by the use of the indicator cocks, as previously explained.

To figure the indicated horsepower of an engine, the mean effective pressure on the piston must be calculated either by means of a planimeter or by drawing a number of ordinates and determining the mean height of the indicator diagram, which, measured in inches and multiplied by the scale, will give the desired figure. Multiplying this by the area of the piston in square inches and the piston speed in feet per minute, divided by 33,000, gives the indicated horsepower developed when the diagram was taken.

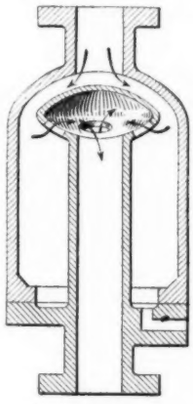
To get a fair idea of the average load and the fluctuations of the governor, more than one revolution should be recorded on the diagrams by holding the pencil on the card during half a dozen strokes of the piston for each end of the cylinder. This will produce diagrams similar to the one shown in Fig. 209. By repeating the process at intervals of half an hour for a whole working day, a good idea of the load conditions can be obtained.

In factories where the power is transmitted to separate departments, floors or rooms, records may be made of the power required for each of them if the engine is indicated as follows: The first set of cards is taken with the full load on, the next set with one room or department thrown off, then with two off, three off, etc., the last set showing only the friction load. After computing the average load of each set of diagrams and subtracting them from each other in the same succession as taken, the load for each department can be found.

[*The next article—the last of the series—treats of the adjustments that must be made to a newly erected engine.*]

## "Knob-Shape" Steam Separator

When rain falls from directly above upon an open umbrella, it does not come in contact with the person holding the umbrella, but runs off the edges and falls to the ground. That is the principle on which the "Knob-shape" steam separator operates. Inside the separator body is a knob-shaped head with ports in the under side. The upper surface is smooth, and upon this the separation of water and steam is effected. The condensation is forced against the outer casing, and the dry steam passes up through the ports and down the center tube, which is surrounded by steam (see illustration). The port area is 25 per cent. more than that of the pipe. This separator is manufactured by the Allentown Experimental Work, Allentown, Penn., and can be had in both vertical and horizontal type.



KNOB-SHAPE SEPARATOR

**To Stop Leakage Through Concrete,** such as tunnel walls, clean the walls thoroughly and paint with a solution consisting of 8¾ lb. of zinc sulphate dissolved in a gallon of water. The zinc sulphate will act on the lime in the cement, forming insoluble calcium sulphate and zinc hydroxide, which fills up the pores in the concrete. Another method is to use one part water glass (sodium silicate) to five parts of water and apply a coat with a brush. Let it dry about six hours and apply another coat. Repeat until four coats have been applied, not allowing over 20 hr. between coats.

**The Loss of Head Due to Curves** and fittings is usually stated in terms of the equivalent length of straight pipe of the same size that would cause the same or equal loss. Experiments show the radius of minimum resistance for right-angle curves to be from 2 to 3 diameters of the pipe. For 6-in. water pipe the minimum loss is about the same as 8 ft. of straight pipe, and for 30-in. pipe about 40 ft. of straight pipe. Intermediate sizes vary between these limits approximately as their diameters.

# The Electrical Study Course—Series Circuits

*SYNOPSIS—The problems given in the previous lessons are worked out, and then an explanation is given of how to find the total resistance of a series circuit consisting of two or more resistances and how to determine the value of the voltage across each section of resistance by Ohm's law.*

The solution to the problems given in the last lesson will be explained in this. One of the best ways to get a clear conception of an electrical problem is to make a diagram and put the known values on it. The conditions set forth in problem No. 1 are shown in Fig. 1. The problem is to find the value of the volts necessary to set up a current of 15 amp. through a coil of 12.5 ohms resistance. By Ohm's law $E = RI = 12.5 \times 15 = 187.5$ volts.

Problem 2 is shown in Fig. 2 and is to find the resistance of a 6.6-amp., 110-volt arc lamp. By Ohm's law

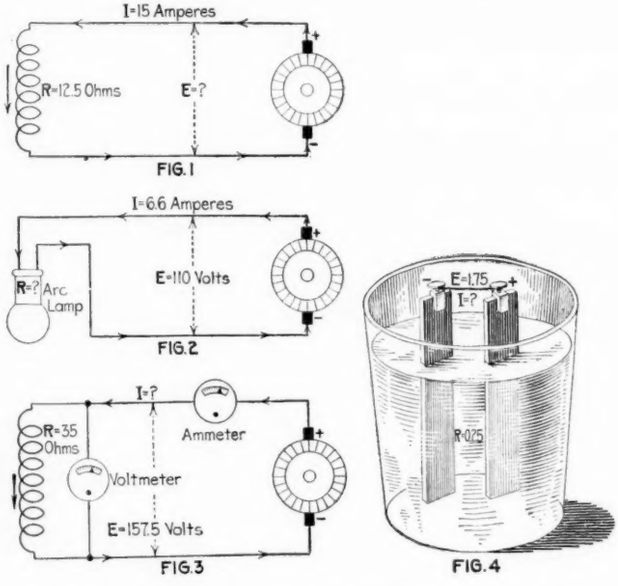
$$R = \frac{E}{I} = \frac{110}{6.6} = 16.7 \text{ ohms.}$$

The third problem, to determine what the ammeter readings should be, connected in a circuit having 35 ohms resistance, when the voltmeter indicated 157.5 volts, is shown in Fig. 3. The solution by Ohm's law, $I = \frac{E}{R} = \frac{157.5}{35} = 4.5$ amperes.

The voltaic cell in problem 4, which is shown in Fig. 4, has an internal resistance from the negative terminal around through the cell to the positive terminal of 0.25 ohm. If the terminals of the cell are connected together by a short piece of copper wire, the resistance of the latter will be so low that practically the total pressure of 1.75 volts will be effective in causing the current to flow through the resistance of the cell, and the current will be $I = \frac{E}{R} = \frac{1.75}{0.25} = 7$ amperes.

At this point a word on just what constitutes an electrical resistance will be in place. In the broad sense of the word, everything is an electrical resistance. Pieces of glass, porcelain or dry wood are resistances of extremely high value. On the other hand, a short piece of copper wire of large cross-section would be a resistance of extremely low value. Where a piece of glass or porcelain of given cross-section and length may have a resistance amounting to billions of ohms, the resistance of a piece of copper of the same length and cross-section would have a resistance of only one-millionth or one-billionth part of an ohm. Nevertheless they are both resistances, the only difference being in the degree that each one opposes the flow of an electric current.

The two cases are extremes and are rarely referred to in practice as being resistances. Porcelain and glass and wood are usually called insulators, although when used on an electric circuit there is always a minute current flowing through them. The resistance of a piece of copper two or three inches in length, of ordinary cross-section, is usually spoken of as a negligible resistance, and therefore can always be neglected in practical problems. Coils wound with copper wire of small cross-section generally have considerable resistance, depending upon the size and length of the wire. Coils and other devices that are constructed for limiting the current through a device, or for other purposes, are usually constructed of materials that have high resistance. High-resistance coils are generally wound of german silver or other special resistance wire. It is worth noting in passing that resistance wires are usually made from an alloy. Resistances that are made to carry large currents—that is, comparatively low resistances such as used for starting large motors—are usually made of cast-iron grids. From




FIGS. 1 TO 4. LAYOUT OF PROBLEMS GIVEN IN THE PREVIOUS LESSONS

this it is seen that there may be an unlimited number of elements, all constituting a resistance to a greater or lesser degree.

In the problems considered so far, only a single element has been connected to the circuit. In practice most circuits are made up of several elements connected in various ways. One of the simplest ways of connecting different devices to a circuit is to group them in series. An element in a circuit may be considered as made up of a large number of sections in series. This will be made clear by reference to Fig. 5, where five separate circuits are shown of 1, 2, 3, 4 and 5 turns respectively. If the cross-section of the wire and the length of the turns are the same in each case, the most logical conclusion would be that the coil of two turns would have double the resistance of one turn. Likewise, the one having three turns will have three times the resistance of the one having one turn, and the one of five turns five times the resistance, etc. In other words, if elements are connected in series, the total resistance is the sum of the individual resistances so connected.

The principle illustrated in Fig. 5 is similar to increasing the length of a pipe line or the length of a coil of pipe through which a fluid is flowing. The longer the pipe is made, the smaller the amount of fluid that will flow through it at a given pressure. If it is assumed that each turn of the coil shown in Fig. 5 has one ohm of re-

sistance, then the resistance of the respective coils will be one, two, three, four and five ohms as shown, and by applying Ohm's law, $I = \frac{E}{R}$, to each circuit when $E = 5$ volts, the current will be 5, 2.5, 1.66, 1.25 and 1 amperes respectively, as indicated.

In Fig. 6 is shown a circuit having two resistances $R_1$ and $R_2$ connected in series. In the preceding paragraph we found that the total resistance of a circuit consisting of two or more elements connected in series is equal to the sum of the individual resistances so connected. Therefore, the total resistance $R$ of the circuit shown in Fig. 6 may be found by the formula: $R = R_1 + R_2 = 8 + 7 = 15$ ohms. The current in amperes equals the total volts divided by the total resistance; that is, $I = \frac{E}{R} = \frac{127.5}{15} = 8.5$ amperes.

Current flowing through a circuit is just the same as water flowing through a pipe, in the respect that, what flows in at one end must flow out at the other. In the problem, Fig. 6, 8.5 amp. leaves the positive terminal of the source and flows through the ammeter $D$, through resistance $R_1$, then resistance $R_2$, back through ammeter $F$ and into the negative terminal of the generator, the same value of current entering the negative terminal that leaves the positive. Therefore the ammeter in the negative side will read the same as the one in the positive. The current is not used up in the circuit, and the same number of amperes (8.5) is effected in each resistance.

A hydraulic analogy of the conditions existing in Fig. 6 is shown in Fig. 7. In the latter the centrifugal pump, pressure gages, flow meters and water motors connected in series, represent respectively the generator, voltmeters, ammeters and resistances connected in series in the former. In Fig. 7, if the whole system is full of water and the pump is driven, the water will be set in motion, and consequently the water motors, which may be used to do mechanical work. All the water that flows out of the discharge will pass through meter $D$, through each motor in series, around through meter $F$ and into the intake of the pump. Consequently each one of the flowmeters will read the same.

If both water motors in Fig. 7 are doing equal work and the pressure at the intake of motor No. 1 is 50 lb. per sq.in., the most logical conclusion would be that the pressure drop through each would be equal. That is, 25 lb. pressure would be used up in motor No. 1 and 25 lb. in motor No. 2. If a pressure gage is placed in the pipe line between the two motors, it would read the difference in pressure between the pressure at the intake and that used up in motor No. 1, or, as we assumed in this case, 25 lb. Likewise, a pressure gage at the discharge of motor No. 2 would read the difference between the pressure indicated on the gage between the two motors and that expended in motor No. 2. We have assumed that the remaining 25 lb. will be used up in motor No. 2, therefore the gage on the discharge of this motor will read zero. The foregoing assumption is not absolutely correct, because there is a loss of pressure in the pipe line itself. This feature will be given further consideration in another lesson. Nevertheless, it serves to illustrate the conditions existing around the two resistances $R_1$ and $R_2$ in Fig. 6.

In Fig. 6 127.5 volts, electrical pressure, is impressed upon the two outside terminals of the two resistances $R_1$ and $R_2$ in series. If a voltmeter $A$ is connected across the terminals of resistance $R_1$, it will read the amount of pressure used up in causing the current to flow through this resistance. Likewise, if a voltmeter $B$ is connected to the terminals of resistance $R_2$, it will read the pressure necessary to cause the current to flow through this resistance, and the sum of the two readings should equal the total pressure across the two resistances in series, or 127.5 volts, just as the sum of the pressures used up in the two water motors in Fig. 7 is equal to that of the

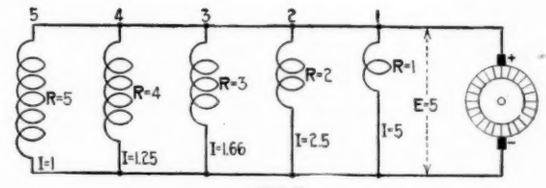


FIG.5

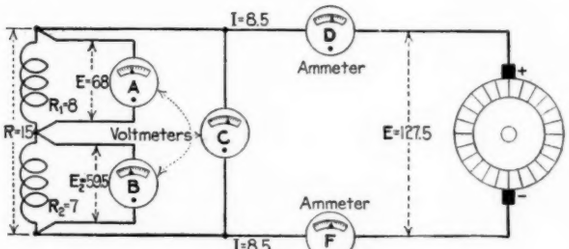


FIG.6

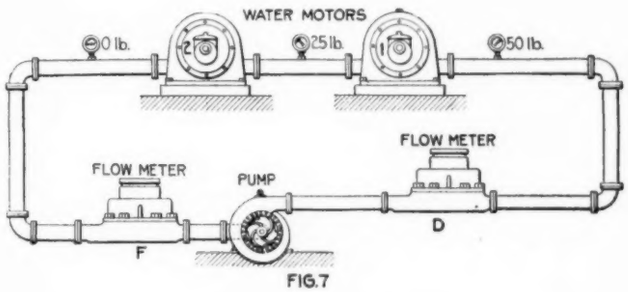


FIG.7

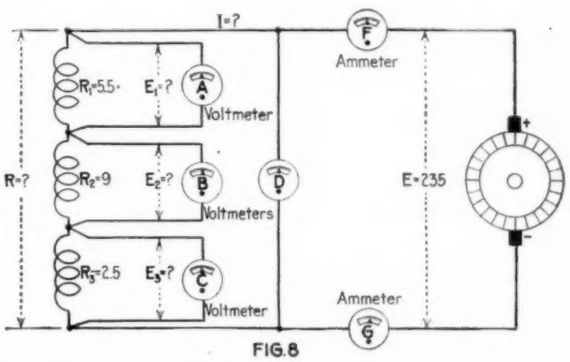


FIG.8

FIGS. 5 TO 8. DIAGRAMS ILLUSTRATING SERIES CIRCUITS

system, or that applied to the intake of motor No. 1. If both resistances were equal in Fig. 6, voltmeters $A$ and $B$ would read the same, but since they are not equal, the voltmeter readings will not be the same, the most logical conclusion being that the greatest pressure would be used in causing the current to flow through the highest resistance. A similar condition would exist in Fig. 7 if one water motor was doing more work than the other; we would expect that the greatest pressure drop would occur through the motor doing the most work.

The value of the volts across each section of resistance in any circuit may be found by Ohm's law, $E = RI$. In Fig. 6 the volts drop across resistance $R_1$ may be expressed as $E_1 = R_1 I = 8 \times 8.5 = 68$ volts. The pressure across $R_2$ is $E_2 = R_2 I = 7 \times 8.5 = 59.5$ volts. The total pressure across the two resistances in series is equal to the sum of the volts across each individual resistance, or $E = E_1 + E_2 = 68 + 59.5 = 127.5$, which checks up with the total voltage on the circuit.

Right here we come in contact with a very important point in the application of Ohm's law. Suppose that $E_1$, the reading of voltmeter $A$, and $I$, the ammeter reading, are known, and it is desired to find $R_1$. This can be done by applying Ohm's law, $R = \frac{E}{I}$, or in this case the expression becomes $R_1 = \frac{E_1}{I} = \frac{68}{8.5} = 8$ ohms. The same is true for $R_2$; that is $R_2 = \frac{E_2}{I} = \frac{59.5}{8.5} = 7$ ohms. Carrying this out one step farther, suppose we know the value of the two resistances to be $R_1 = 8$ ohms and $R_2 = 7$ ohms, as in the figure, and then take voltmeter readings across each section and obtain for $E_1$ 68 volts, and for $E_2$ 59.5 volts. From either one of the sets of values we may find the value of $I$; that is, $I = \frac{E_1}{R_1} = \frac{68}{8} = 8.5$ amperes, or $I = \frac{E_2}{R_2} = \frac{59.5}{7} = 8.5$ amperes. Hence it is evident that it is not necessary to know the total resistance of a circuit and the total voltage applied to it to obtain the current. All that is necessary to know is the value of one section of the resistance and the voltage drop across this section to determine the value of the current.

In applying Ohm's law formulas to finding the various values of the different sections of a circuit, care must be taken to use the values in the calculations pertaining to the section being considered.

Fig. 8 gives the study problem: In addition to finding the values indicated by the question marks on the figure, state what each instrument will read and also find the value of $I$ by using the resistance and volts drop across each section, and check the voltage calculations by the sum of the volts across each section of resistance.

**Drains for Steam Pipes** should be provided at all points where it is possible for water to accumulate. Some may be for use only when putting the line into service, but are necessary at such times. Drains from points where there is even slight difference in pressure should not be joined together or to the same trap, as the difference will prevent the proper operation of the one of lower pressure. If a still lower pressure or constant discharge is maintained beyond the point of junction, as in the Holley loop, the foregoing does not apply.

**Draft in Steam Boiler Practice**—In Fig. 1 (on page 374 in the issue of Mar. 20), on the curves marked "temperatures of external air" the values should be reversed to read 90, 70, 50, etc., from left to right to conform to the fact that the lower the external air temperature the greater the draft.—Editor.

# Heat Loss from Bare Steam Pipes

By L. B. McMillan

Following is a tabulation of the results and values arrived at, by the various experimenters named, in tests to determine the heat loss from bare steam pipes at various pressures and temperature difference under the conditions given in the full text. Assembled in this form the best information to date is available, and the references to the full report of the tests as conducted should enhance its value.

BARE PIPE HEAT LOSSES

| Authority | Pipe Size | Temperature Difference Deg. F. | B.t.u. per Sq.Ft. per Deg. Temp. Dif. Hr. | Kind of Test |
|---|---|---|---|---|
| G. M. Brill, Trans. A.S.M.E. Vol. 16, 1895, p. 827 | 8-in. | 269 | 2.706 | Steam Condensation |
| Geo. H. Barrus, Trans. A.S.M.E. Vol. 23, 1902, p. 791 | 2-in. | 305.2 | 3.366 | Steam Condensation |
| | 2-in. | 273.2 | 3.081 | |
| | 10-in. | 295.4 | 3.220 | |
| C. L. Norton, Trans. A.S.M.E. Vol. 19, 1898, p. 729 | ..... | 318 | 2.61 | Electrical |
| Stevens' Indicator, Vol. XIX, p. 388 | 2-in. | 274.6 | 3.13 | Steam Condensation |
| Jacobus, Vol. XVIII, p. 240 | 2-in. | 229.6 | 2.78 | Steam Condensation |
| Chr. Eberle, Verein Deutscher Ingeneur, Mit über Forschungs Arbeiten, heft 78 | 70mm. —2.75in. | 213.5 | 2.68 | Steam Condensation |
| | | 214 | 2.68 | |
| | | 212.1 | 2.68 | |
| | | 257 | 2.88 | |
| | | 260 | 2.88 | |
| | | 251.9 | 2.97 | |
| | | 298.5 | 3.11 | |
| | | 304.2 | 3.15 | |
| | 150mm. —5.9in. | 203.3 | 2.68 | |
| | | 199 | 2.66 | |
| | | 235.6 | 2.89 | |
| | | 238 | 2.90 | |
| | | 288.4 | 3.23 | |
| | | 279.6 | 3.23 | |
| L. B. McMillan, Trans. A.S.M.E., Vol. 37, 1916, p. 921 and Power, Apr. 4, 1916 | 5-in. | 50 | 1.950 | Electrical |
| | | 100 | 2.152 | |
| | | 200 | 2.665 | |
| | | 300 | 3.260 | |
| | | 400 | 4.035 | |
| | | 500 | 5.180 | |
| Thomas Box, * Practical Treatise on Heat, and Kent's Handbook... | 5-in. | 54 | 1.464* | Calculated from Dulong & Peclet's Equations and Tests |
| | | 108 | 1.697 | |
| | | 162 | 1.884 | |
| | | 216 | 2.087 | |
| | | 270 | 2.302 | |
| | | 324 | 2.556 | |
| | | 378 | 2.831 | |
| | | 432 | 3.146 | |

* These results are of importance mainly for their historical interest, as Paulding ("Stevens Indicator," Vol. XIX, p. 393) has shown that modern tests prove that Peclet's coefficient of radiation (0.64) is too low. It should be about 0.87.

THE FIREMAN THINKS HE COULD FILL THE CHIEF'S CHAIR, BUT HE WOULDN'T CAST A SHADOW. THERE ARE OTHERS

# Editorials

## The President's Plea to the People

The press of Monday, Apr. 16, contained President Wilson's plea to the laborers, skilled and unskilled, to the farmers, to the manufacturers and merchants, to buckle down to the business of giving in this terrible struggle for liberty and democracy all that they can give in the most efficient, abundant and unselfish way.

It would seem that the American people do not yet realize adequately the magnitude of the struggle. There is an all too-widely entertained notion—and notion only it is—that a few months will see the Prussian crushed 'neath the valorous heel of Democracy. The wish is father to the thought. There are reasons aplenty which furnish worthy evidence that the conflict will not end in a few months, and it will surprise many conservative men, men competent to judge, if it ends in two years. Who that knows anything of this world's history believes that monarchy can be driven forever from the earth months sooner than it would otherwise have been simply because valorous, spirited, but unprepared America takes up the task she began one hundred and forty years ago?

The method of raising money which Germany and her allies have adopted to carry on their war is such as to put off to an uncertain day the payment of the war debt. There is no taxation method, no pay-as-you-go system such as America and her allies have adopted. Germany yet hopes to emerge shattered but victorious. She hopes yet to pay her enormous debts with indemnities levied upon her vanquished foes. And now that America has entered—rich, fabulously rich America—how great, thinks the incomprehensible Teuton mind, will be the indemnity collected from her.

In all there are probably at least fifteen million men actually engaged in conflict, with as many or more in reserve. It has been estimated that nearly five millions have been killed and six millions incapacitated. For every man at the front ten are required in the service army to keep him there. During one time on the Somme front an area thirty-six miles long and ten miles wide was congested with auto trucks and horse-drawn vehicles loaded with food, fodder, ammunition and supplies for that one front. Engineers are sufficiently acquainted with machine-shop work to know what labor, material and time are required to turn out even a single shell of any caliber one may name. An idea of the rate of their consumption is had from the report that on the eastern front the Germans in four hours dropped in a relatively small area ten thousand tons of projectiles. In her airplane schools, where she teaches her aviators the art of flying, France alone loses an average of twenty-five 'planes a day. One could go on reciting such stupendous figures indicative of the magnitude of the struggle; but these will suffice.

We need to send men to France, thousands of them, and that we will soon is the wish of most Americans. But it is our material resources—food, coal, machinery, ships, etc.—that are of more immediate importance. We must economize. And here is the President's message as power-plant men must see it applied to their everyday work. This woeful waste of fuel under steam boilers must stop. Such conditions as make a boiler efficiency of but thirty per cent. and upward to the excusable sixty per cent. must stop. Wastefully leaking setting, holes in the fire, dirty boilers—a lazy, shameful state of affairs—must be checked. Hot water as from returns, etc., much of it fit for boiler feed, must be used for boiler feed instead of going to the sewers and streams. Leaks, so many of which there are about the usual plant, must be repaired. Only a minimum of combustible must be allowed to go through the grate to be carted away with the ash.

It now becames as much a patriotic duty to run a plant as it should be run as it is the duty of men best suited for the work of soldiers to enlist in our armed forces. Engineers and firemen can serve Old Glory by doing their work so that there will be no uncalled-for waste. We know they will so do it.

## Wanted, Steam Engines!

The Government, or companies operating at the instance and with the coöperation of the Government, want steam engines—thousands of them—to drive 3000-ton wooden vessels.

In men and guns and ammunition the Central Powers are overmastered by the Allies. The nations unprepared for the organized and carefully planned and munitioned assault of 1914 have held the assailant more or less in check until they have developed armies and means for supplying them and have evolved leaders and unity of purpose and of action.

The weight of military power is now with the Allies. Germany has now but one hope. If she can hold her lines intact, though slowly receding, if she can induce her people to continue to hunger and to sacrifice, until she relentlessly shoots up the shipping of the world so that her enemy's supply of food and ammunition is shut off, she may be able to stipulate terms of settlement which will bring some return for all the blood and treasure that have been expended in the "defense" of the Fatherland. Her remaining advantage is her highly developed submarine service.

There are two ways to combat this purpose. One is to cripple the submarines, and the other is to build ships faster than the enemy can destroy them. America invented the submarine, and Yankee ingenuity ought to be able to devise an effective way of hunting it down. The best service that scientists and inventors can render to the world now is to multiply means for locating and incapacitating these skulkers that shoot from ambush alike at friend and foe, at noncombatant as well as belligerent.

The builders of steel vessels are working up to the extent of their capacity and the material which they can

get, but America is rich in lumber and can build wooden vessels by the thousand. She has already started to do this.

The suggestion of F. Huntington Clark, mentioned in the issue of Mar. 27, has taken root, and all that we can put together of two- to three-thousand-ton wooden vessels will be put into service with the utmost possible dispatch. These will be submarine fighters as well as cargo carriers. On account of their low visibility it will take many more submarines to cover effectively a given area, and when one is destroyed, it will mean less than a "Lusitania."

But such vessels must have engines. The oil engine would be the ideal motor power, but we cannot make them fast enough. There are, however, lots of steam-engine shops that, before the war at least, were not any too busy. Here is a chance for them to utilize their equipment for their own profit and their country's good. Who will take from the Government, or from companies building such vessels, contracts to turn out marine engines from designs that will be furnished? How fast can you make them? How many will you undertake, and how soon can you get started?

⁂

## The Control of Electric Motors

The duty of the controller is not alone to properly accelerate the motor and its load, but also to supply those functions that cannot be efficiently incorporated in the latter. The problem of motor control is almost as old as the electrical industry, and its importance is evidenced by the countless schemes that have been developed to meet the multitudinous applications of the electric motors. Although the electric motor has been developed to a very reliable and efficient machine, its successful application to many drives has been largely a matter of the proper type of controller.

Owing to the care that had to be taken in starting the early types of direct-current motor to prevent sparking and flashing at the brushes, there grew up the idea that the more steps used in cutting out the starting resistance the better the starting device. One of the outgrowths of this early idea was the faceplate type of starters, which is so widely used today both in the manual and the automatic type, although at the present time the latter is being rapidly superseded by other types.

The modern tendency is fast getting away from the early idea—the more steps used in cutting out the starting resistance the better the controller. Among the reasons for this are the ability of the modern motor to operate under the most severe starting conditions without sparking, the increased capacity of electric-power systems; thus removing the danger of disturbances to the supply voltage, and the tendency to make the starting of all motors automatic. This last factor is influenced very largely by the price of the hand starter.

It has been realized in general that the compound and series motor could be accelerated much more rapidly than the shunt. It would seem, however, from the results of a series of tests made by H. D. James and presented in a paper at the midwinter convention of the American Institute Electrical Engineers Feb. 16, an abstract of which appears in another part of this issue, that the shunt motor is also capable of being started rapidly even under full load. Starting a twenty-horsepower, seven hundred and fifty revolutions per minute shunt motor under full load, applied through a prony brake, by cutting out the starting resistance in one step is a radical departure from general practice and is a feature that is worthy of the attention of all who have to do with the application of electric motors. A very important point brought out by these tests, and one that is not generally appreciated, is that if the motor's field is zero when the line switch is closed, the starting torque has a very small value and increases gradually, so that the motor or its load will not be subjected to a heavy shock when the lost motion is taken out of the drive. This would seem to remove the most serious objection to the rapid acceleration of the motor and its load. If it is possible to accomplish in general practice what these tests show, even though there are special cases that require special treatment, it will be possible to construct automatic starters almost as cheaply as hand starters, therefore eliminating the most serious problem confronting the universal use of the automatic type.

⁂

## Uniflow Engine Patent Decision

Notwithstanding engines with admission valves at the end of the cylinder and central exhaust ports, controlled by the piston, have been known for years and are the subjects of several expired patents, Judge Hazel, of the United States District Court for the western district of New York, has just upheld the Stumpf patents in a suit brought by the American representatives of Professor Stumpf against the A. Schreiber Brewing Co., of Buffalo for infringement by the use of a uniflow engine built by the Skinner Engine Co.

The Stumpf representatives claimed that the professor, realizing the importance of cylinder condensation, had provided means for keeping the admission end of the cylinder hot and dry, and in order to minimize the carrying off of heat by the exhaust, had provided for keeping the exhaust belt as cool as possible. The combined use of an inlet port, an exhaust port distant therefrom, means for heating the steam within the cylinder near the inlet port, a relatively cold chamber into which the exhaust port leads and an elongated piston working in the cylinder and adapted to uncover the exhaust port as the piston nears the end of its working stroke and to keep said port closed and to cover and protect the adjacent interior portion of the cylinder during the remainder of the operating cycle constitute the Stumpf invention. Other engines have had central ports, others steam jackets, others elongated pistons, but it remained for Professor Stumpf to combine these elements in such a way as to materially reduce the internal losses of the steam engine and make large ratios of expansion in a single cylinder practicable. The hearings brought out much interesting material concerning the history and development of the uniflow engine, which we hope to review in an early issue.

⁂

There were those who seven years ago thought we were real mean to blow cold on Mr. Whitney's exploitation of Rhode Island coal and Mr. Williams' catalytic method of burning it. The New England papers are now publishing the following:

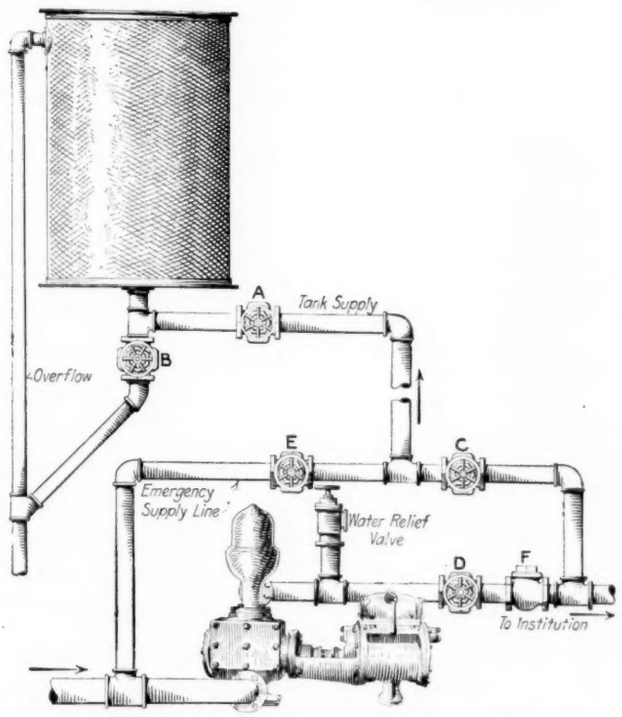
**A petition for the sale of the personal property of the Rhode Island Coal Co., now called the Portsmouth Coal Mining Co., has been filed in the Rhode Island Superior Court to secure the amount of $24,475 and costs to pay the rent and taxes of the premises.**

# Correspondence

## Two-Pressure Water Supply

The illustration shows a system of piping for supplying direct water pressure from a pump part of the time and from an elevated tank when the pump is not in operation.

The water leaving the pump passes through valve *D* and check valve *F* into the water main supplying the institution, as well as up through valve *C* on the feed line to the tank. As soon as the tank is full, valve *C* is closed and the pump discharges directly into the mains; in case of fire valve *E* is opened and the water from the tank flows into the suction line of the pump and is used to help out the regular water supply. Then by changing




PIPE CONNECTIONS TO TANK AND HOUSE SERVICE

the pressure regulator and the relief valve, the pressure in the mains can be raised to the safe limit. In such an emergency simply shut off the pressure regulator and plug the outlet to the relief valve and run the pump by the throttle. By having the tank-supply line enter the bottom of the tank as shown, there will be only the one connection needed, as the supply line can be used for draining the tank by closing valve *A* and opening *B*.

The water-relief valve is placed between valve *D* and the pump so that in case the pump is started with *D* closed, it will release the pressure; also, when the pump is working, it will release the pressure on the mains in case the pressure regulator gets out of order. The check valve is to take the jar off the pump valves when the pump piston has reached the end of its stroke, and also, in case *D* is forgotten and left open, it will keep the water from wasting through the pump. In daily operation *C* is closed when the tank is full, and at night it is opened and *D* closed when the pump is stopped. The water-relief valve should be set 5 lb. higher than the pressure regulator, as it is annoying to have the relief valve opening every few minutes.

GEORGE L. BRUNING.

Warwick, R. I.

## Co-operation Versus Competition

It is said that fully one-half of the actual investment represented in the physical equipment of a central station is in service for not more than 10 per cent. of the time. This means that half the plant can carry the load for 90 per cent. of the year, the rest of the equipment standing idle except during the dark days of winter when the extra lighting load comes on early in the afternoon and is superimposed on the regular power load. It is to carry this peak during these comparatively short periods that so much additional capital invested in equipment is required. This is no great hardship to a central station if permitted, by public service commissions, to earn a fair return on the entire capital invested, regardless of how excessively high the rates must be kept.

On the other hand, a private plant of moderate size contains probably three units, one or two operated during the daytime and one at night. This means that one-third to two-thirds of the equipment is idle all the while. Obviously this is uneconomical and requires a larger investment than is necessary except to provide against the possibility of a shutdown.

It is evident that in large cities there will continue to be much duplication of machinery and excess capacity as long as there is no coöperation between the central station and the isolated-plant interests. If, however, during the cold months large buildings generated their own current and heated with the exhaust steam, at practically no additional expense, and could shut down their plants in summer and purchase current from the central station, this would mean that in the private plant with its connection to the central station additional capacity in generating equipment would be unnecessary. The central station, on the other hand, would be able to offer to these buildings in the warm months, when the demand for electricity fell off, a rate so low that these private plants could be profitably shut down. In other words, the central stations should be willing to smooth out their load curves by filling in the valleys occurring at night in the winter and all the time in summer by carrying the isolated-plant load when shut down during these periods. At the same time the isolated plant could depend on the central station for breakdown when necessary. The present tendency toward duplication of equipment and machinery would in this way be avoided, and it would be possible to secure more economical methods of operation with all plants operating nearer to capacity.

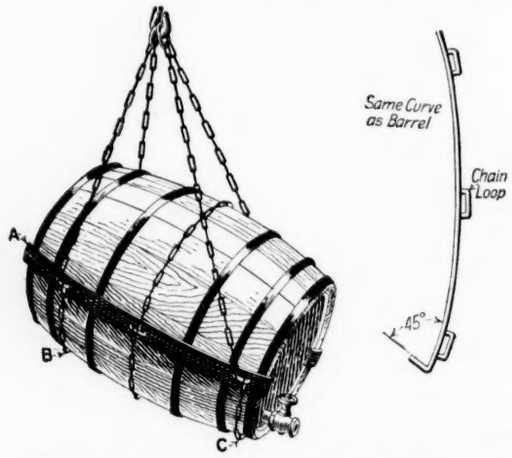
It would be a relatively simple matter to arrive at rates for electricity based on cost of service in such an

event, as such service during the off-peak period could be based on the operating cost only, for no fixed charges should be added because all the generating equipment would be needed in any event for the winter load. If, however, a private plant, because of accident or for any other reason, required service in winter during peak-load hours, a very high rate would be justified and would prevent the use of service except when absolutely necessary, in which case the price would not be the controlling consideration. Time-recording meters would show when current was taken, and bills would be rendered accordingly. Annual minimum demand could be established in order to assure a satisfactory revenue from each building connection. Such a coördinated system of operation has, of course, been discussed by others, but the idea seems so practical and sound that it deserves greater attention. Labor is and will continue to be scarce, and every means should be used to conserve our resources and to prevent useless duplication of equipment. Even a cursory study of the economies of this situation will convincingly demonstrate the wastefulness of present methods. Co-operation should be substituted for competition between central stations and private plants in order to eliminate duplication and waste. RAYMOND W. BRISTOL.

New York City.

## Transferring Oil to Tank

To empty barrels of heavy engine oil by the hand-pump method in cold weather is "some job" and led to making the following rig, which eliminates much of the labor. Two pieces *A* of iron $\frac{3}{8}$ x $1\frac{1}{4}$ in. and 1 in. longer than the




BARREL ELEVATED READY TO BE EMPTIED

barrel were bent as shown, the 1 in. extra length being bent back at about 45 deg. to hook over the edge of the barrel. The chain loops are of $\frac{3}{8}$-in. round with the ends put through the drilled holes and riveted on the inside of the side pieces, or "spacers," and are about 5 in. from the ends. The "cradle" chains *B* and *C* are the length of half the circumference of the barrel near the ends. The length of the four sling-chains depends upon the angle at which the barrel is to hang. It may be wise to extend the chains over the top or around the barrel or to put one in the middle fastened with a clamp to guard against the barrel tipping over. A short nipple with a valve is screwed into the head of the barrel to regulate the flow of oil. R. F. HAMILTON.

Casper, Wyo.

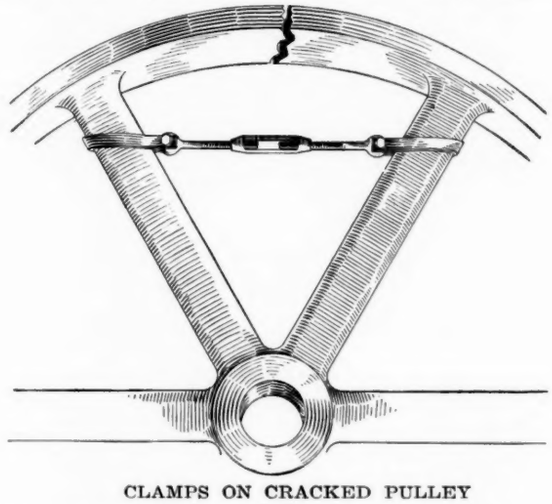
## Hunting Governor Cured

A 20 x 24-in. four-valve engine driving a 200-kw. three-wire generator at 150 r.p.m. gave trouble by racing, the voltage fluctuating as much as twenty volts after the unit was up to speed. The difficulty was found to be in the governor dashpot and the cause of the erratic action was that an air pocket had formed in the dashpot when the stuffing-box worked loose enough to allow some of the oil to escape. When the dashpot was completely filled with oil and the cap secured, the engine governed within one or two revolutions and steady voltage was obtained.

Philadelphia, Penn. EDWARD T. BINNS.

## Emergency Pulley Repair

During some changes and additions to our power plant a pipe fitting was accidentally dropped on an iron pulley that drove a low-pressure air fan, making a crack across the face midway between two of the spokes. As



CLAMPS ON CRACKED PULLEY

it was a special-diameter pulley (about $31\frac{1}{2}$ in.), it could not be readily duplicated. The pulley was strengthened by making up a couple of clamps, which were fitted about the two arms adjacent to the crack and then drawn tight by means of a turnbuckle which drew the broken rim tightly together in its former position. Before drawing the break together, we wiped the inside of the crack with sal ammoniac to get the benefit of any rusting action. The pulley was put in operation a few days later and has seen everyday service since. M. A. SALLER.

Philadelphia, Penn.

## A Fouled Feed-Water Heater

Considerable is written about the necessity of keeping the heating surfaces of boilers and the cooling surfaces of surface condensers clean, but little is said about cleaning the heating surfaces of the closed feed-water heaters.

By comparing the temperatures logged a couple of years back we found that we were not obtaining good results from our feed heater, so I decided that there must be some badly fouled tubes in it, for there was no record of cleaning the heater to be found. The best results were 180 deg. with a back pressure of 10 lb. under normal conditions. On examination matters were found worse than expected. The surfaces of the tubes near the exhaust inlet were heavily coated with grease carried in with the

exhaust steam and at the bottom of the heater there were lumps of heavy black grease and sediment.

The heater was filled with water to within a few inches of the top, and 25 lb. of a standard boiler compound was mixed and added to the water. Steam was admitted to the bottom of the heater through a hose connected to live-steam pressure of 25 lb., and the overflow of scum and dirty water was allowed free escape from the top of the heater. During each of the first six hours more compound was introduced at the rate of 5 lb. an hour. The condensate from the steam used for boiling kept a steady overflow for ridding the scum; after 18 hours' boiling the steam hose was disconnected and the heater was flushed out with clean water under 60 lb. pressure. When the heater was put back in service the feed temperature increased to 210 to 240 deg. F. with a back pressure of 8 to 10 lb. gage.

Perhaps there are others who have forgotten to inspect their heaters and are overlooking a preventable loss.

Concord, N. H. H. C. WILLIAMS.

## Do High Coal Prices Justify High Electrical Rates?

On page 462 of your issue of Apr. 3, you state:

**The president of a public-service corporation protests with vehemence against any further "crowding" on the part of the Public Utility Commission on account of the increased price of fuel. To those who know that the station cost of putting a kilowatt-hour on the switchboard is less than a cent, while the charge to the customer is 10 cents, the vehemence is somewhat forced.**

It seems to me that this paragraph was written by one who either did not know the facts or wished wilfully to misstate them.

1. There are very few steam stations that can produce power at one cent at the station bus, considering development costs, proper depreciation, fixed charges, taxes, administration and manufacturing costs at the present high cost of fuel and equipment.

2. Customers are not at the station bus, but must be supplied often through long distribution lines, costly to build and to maintain.

3. The charge mentioned of ten cents is one now seldom made except in communities where the demand is small.

Your article should have stated rather that the price of all articles, food, clothing, and supplies had steadily advanced in the last few years, while in the same time the asked price for power has steadily declined and the price of a street-car ride with even increased lengths of rides, comforts and conveniences, has remained the same, even in the face of the extraordinary increase of the price of all raw material. FRANK H. MILLER.

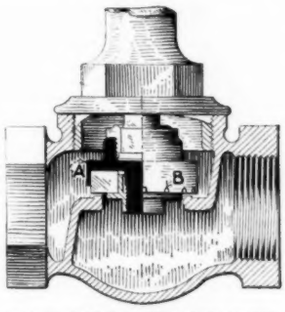
Louisville, Ky.

[The item in question plainly said "that the *station* cost of putting a kilowatt-hour on the switchboard is less than a cent." This does not include fixed charges or expenses of distribution and administration, but it does include labor, oil, water and other supplies *besides* the fuel. If the price of fuel were doubled, it would make a difference of only a fraction of a cent in the cost of making and delivering and collecting for a kilowatt-hour, and any pleading of the high price of fuel as an excuse for warding off an inquiry with regard to the justice of existing rates by the public-service commission in a state where the rate to small consumers is ten cents is laughable to those who know the conditions.—Editor.]

## Keeping Disk Valves Tight

In our plant we have a large number o. disk valves, and on account of the service to which they are subjected, the disks have to be replaced and the seats ground frequently to keep them tight.

The valves are connected to cooking kettles, and except when starting they are kept almost closed. As a result the steam flowing through the small opening soon cuts the seat. After the raised valve seat is ground down several times, replacing the disk does not keep the valve tight long, as the disk holder, which comes about flush with the disk, strikes the base of the seat and prevents the disk from coming in contact with the seat itself. By filing the disk holder as at *A* so that the disk projects out about $\frac{1}{16}$ in., we get longer service from the disks.



HOW THE DISK HOLDER WAS CHANGED

Another method we use is to put two valves on the line to each kettle. The one with a disk is kept either wide open or closed, and the other, a diskless valve, has slots *B* cut into the disk holder or in the valve seat so as to pass only enough steam to keep the kettles hot. The second valve can be any of the discarded ones that has had its seat ground down in service.

Using a little cylinder oil on the valve stems will keep them from undue wear at the threads and prevent the packing from drying out. W. CHUISANO.

Brooklyn, N. Y.

## Steam Heating in Conservatories

Because the nature of the service requires close regulation, even distribution of heat and not too high temperture near the plants, greenhouse-heating problems are in some respects more difficult than the ordinary office-building job. In one case where the sections under glass are about 150 ft. long by 20 ft. wide, with 10 to 15 houses in a group, the 1-in. heating pipes extend the entire length along each side, suspended under the benches or flower beds. It is difficult to avoid slight traps in the piping from settlement or sagging. Increasing the steam pressure is not permissible for several reasons, the most serious being that the higher temperature is objectionable, the piping becomes corroded on the outside from frequent sprinkling and high pressure is not safe; and the hand-regulated valves must be kept nearly closed and consequently soon become cut. In the original installation the condensate was discharged into the sewer through pot traps in a more or less decrepit state. It is a well-known fact that no matter how perfectly a trap may work, considerable steam will rise from the water discharged, and the higher the steam pressure the higher will be the temperature of the water and of course more will flash into steam when released. In cold weather steam could be seen escaping from the sewer vents for a considerable distance.

The first move to utilize this heat was to discharge each trap through a series of "secondary" pipes, hung below the regular heating pipes, of large size so that the

water would travel slowly through them and give up as much of its heat as possible. Since some of the houses contained tropical plants requiring a high temperature and others had plants calling for lower temperature, it was possible to discharge into the tropical house first and to the other houses "in series" so that the water emptied into the sewer at about 85 deg. F.

To insure circulation at the lowest possible steam pressure and also to deal with low temperature, the returns were later brought to a central point and connected to a tank kept under about 10 in. vacuum and pumped from there back to the boiler house.

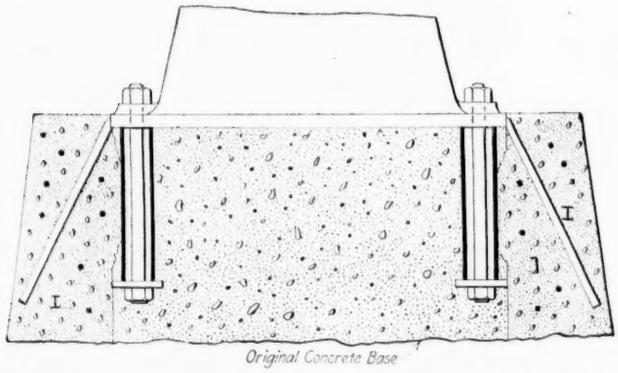
Several good things were accomplished by this arrangement. The best, perhaps, was the economy or good use of the heat, since in some houses where four or five of the 1-in. pipes were formerly used from one to three would do the work with the "secondary" pipes. Another improvement and one that pleased the gardener, was the lower pressure and temperature; and finally, the cost of pumping the water back to the boiler house—about 2000 ft.—was offset by the good, scale-free feed water, for scale and the labor and cost of boiler cleaning were reduced to the minimum.

The general principle of the foregoing applies to secondary heaters or "economy coils," which may be profitably employed in many buildings, especially where there is a vacuum system already in use, in which cooling water must be used, resulting in more return water than can be utilized, which is therefore wasted.

New York City. J. Lewis.

## Foundation Reinforcement

A small engine showed signs of leaving the foundation during a run, and a crack near the head end of the base looked so serious that the engine was shut down. Investigation showed that the foundation was practically the same length and width as the base and the foundation bolts or pipes surrounding them were so close to the corners of the foundation that the concrete around them had cracked away, leaving part of the pipes exposed.




ADDITIONAL CONCRETE AROUND OLD FOUNDATION

It was decided to strengthen or reinforce the foundation in the following manner: A trench 1 ft. wide was dug around the foundation and filled with a rich concrete mixture and all kinds of scrap iron, to reinforce the corners—thus making a solid sleeve around the foundation. Iron bars were placed as shown to prevent any fore-and-aft motion of the base. The bolt pipes were filled with a rich mixture of cement and the nuts then run down tight on the base, and although the crack in the base was not welded, there is now no movement of the base when the engine is running. L. L. Cronin.

Omaha, Neb.

## Attaching Rubber Hose Coupling

Among the jobs that are difficult when not gone at in the easiest way, but that are easy when done right, is that of attaching a coupling to a rubber hose. Following is my method:

Heat the coupling in a forge or with a blowtorch to a dull red and, holding it with a pair of tongs or pliers, thrust it into the hose end, held firmly in a vise or by other means. Then promptly plunge the hose end and coupling into water. The heat of the coupling will vulcanize the rubber to it, and after affixing the clamps it will be impossible to pull it off if the job is well done. I have used this method many times and find it easy and satisfactory. E. L. Davis.

Rosedale, Kan.

## Protecting Extension Cord

The letter on "Boiler-Room Electrocutions," by R. K. Long in the issue of Mar. 13, page 363, prompts me to call attention to a means of safety always employed by me since working in a plant where one man, while washing a boiler was electrocuted by coming in contact with the exposed wire of an extension light cord connected to an ordinary lighting circuit carrying 110 volts.

To prevent another such accident, instead of wrapping the cord with friction tape as suggested by Mr. Long, I pass it through a $\frac{1}{2}$- or $\frac{3}{4}$-in. light rubber hose of sufficient length to cover the cord that is used inside of the boiler or in wet places where a man must work. The ends of the hose can be wrapped with a few turns of friction tape to exclude water and prevent slipping. Protected in this manner and using a waterproof socket, the cord is just as easily handled, is only a trifle heavier and is safe. M. Papworth.

Cleveland, Ohio.

## Repairing Cut Pump Valves

In the plant of which I have charge, the metal valves of the boiler-feed pumps became leaky after a few months' use, owing to the sediment in the returns from the heating system. Up to last spring, I always removed the valves and seats and faced them off on a lathe, and this necessitated buying new ones quite often. It occurred to me that tinning the faces of the valves and seats, filling them with solder, then scraping the solder down even with the surrounding metal and grinding a very little with emery would make them as good as if they were faced off; in that way the same valves and seats could be used indefinitely, and I am pleased to say the experiment has been entirely satisfactory, for it saves a lot of time and expense.

Perhaps this is not new with other engineers, but I had never heard of it. It may help some who have similar trouble. John W. Hilfrank.

White Plains, N. Y.

# Inquiries of General Interest

**Mud Ring of Vertical and Locomotive Boiler**—What is the mud ring of a vertical or a locomotive boiler? E. F. A.

The term "mud ring" is often employed to mean the same thing as furnace ring, firebox ring or water-leg ring. It is the ring of rectangular section, usually of wrought iron or steel, forming the lower boundary of the water-leg and to the inside and outside of which the furnace- and outside water-leg sheets are secured by through rivets.

**False Water Line of Steam-Heating System**—What is meant by a false water line of a steam-heating system? J. L.

The term is generally used in connection with a low-pressure live-steam heating system in which the boiler is so placed that in order to seal the returns, a trap has to be formed in the return line, requiring the return water to fill the returns up to a "false water line" of higher level than the water line of the boiler.

**Dynamic Braking of Induction Motors**—Has any scheme been developed for the successful dynamic braking of induction motors? W. W. B.

No successful means appears to have been developed whereby dynamic braking action can be successfully utilized in stopping induction motors. Attempts have been made to attain this end by admitting direct current to the stator winding after the primary current has been cut out, but this has never proved very successful.

**Source of Tripoli Polish**—What is the raw material from which tripoli polishing powder is derived? H. H.

Tripoli is a silicious deposit composed almost wholly of the shells of diatoms from which the calcareous matter has been washed out by the action of water, and it occurs in soft masses called tripoli stone, or in earthy form known as tripoli powder. "Tripoli" takes its name from the place, Tripoli, Africa, where deposits of the kind are found. It is also found in various parts of the world, and there are some deposits in the United States.

**Gumming of Diesel-Engine Piston Rings**—How can I keep the piston rings of a vertical Diesel engine free from gumming? A. G. B.

Gumming of the piston rings is usually attributable to excess lubricating oil. To keep the rings free, some manufacturers recommend squirting kerosene into the cylinder through the indicator hole upon shutting down the engine, while it is allowed to stand idle for some hours. Care should be taken to keep the admission valves open during this time so the kerosene can evaporate.

**Winding Field Coils with Enameled Wire**—Is it good practice to use enameled wire for the winding of field coils, and if so, what are its advantages over cotton-covered wire? C. M. C.

Enameled insulated wire is used very largely today by different manufacturers not only for winding field coils but also for solenoid coils and similar uses. Enameled insulated wire has the advantages over cotton-covered of higher insulating qualities, greater heat-dissipating capacity and of requiring less space, therefore less copper, for a given number of ampere turns.

**Small Water Surface for Disengagement of Steam**—How does small steam-disengagement surface of water in a boiler affect the quality of the output of steam? W. R.

When the surface is small in proportion to the amount of steam formed, the larger number of steam bubbles rising through the water and bursting in a given area cause more of the water to be projected into the steam space. Small particles of water thus become suspended in the steam, and the boiler will have an output of wet steam unless this unevaporated water that is held in suspension is first separated by gravity, or some mechanical means, or it receives additional heat for its evaporation.

**Types of Oil Burners for Boilers**—What are the different methods of operation of oil burners used for boiler furnaces? W. F.

Each of the different types of oil burners is designed to atomize the oil as nearly as possible to a gaseous state. The three general classes according to their method of operation are: (a) Spray burners, in which the oil is held in suspension and forced into the furnace by means of a jet of steam or compressed air, and designated as "outside mixers" or "inside mixers" according to whether the oil and the atomizing medium are brought together outside or inside of the apparatus; (b) mechanical spray burners, in which the oil, previously heated to 150 deg. F. or higher, is forced under pressure through a nozzle and is broken up into a fine spray; and (c) vapor burners, or carburetors, for use with refined oils and in which the oil is heated and volatilized, then admitted to the combustion chamber, are used in some special applications.

**Effect of Enlarging Feed Pipe**—If the 1-in. discharge pipe from a closed feed-water heater is replaced by a 1½-in. pipe, can the feed pump be run slower, or will the feed water be delivered to the boiler at a higher temperature? C. F. M.

The speed of the water through the heater, and thus the heat taken up, would be the same irrespective of the size of the delivery pipe. The speed of the pump would be the same to furnish a given amount of water irrespective of the size of pipe conveying it. This does not take account of such minor and indeterminate factors as greater radiation from and less friction in the larger pipe.

**Trouble from Taking Up Boxes**—Considerable noise made by a high-speed engine was stopped by setting up the main boxes and connecting-rod brasses, but after running for about a quarter of a day, there was more noise than before making any changes and it was found impossible to return to running conditions that were as good as those before any adjustments were made. What can be suggested as the reason for failure to return to the original running conditions, and how can the running be improved? C. H. E.

Taking up the bearings, especially if it resulted in their becoming overheated, has changed their size and shape and also would have the effect of changing the character of the rubbing surfaces. The tightening should have been done gradually and without overheating, and the running conditions of the engine may still be open to improvement made in that manner, but if not, recourse must be had to more effective cushioning on the exhaust or refitting the bearings.

**Alternator Running Without Field Excitation**—We have two steam-turbine-driven alternators, one 6000- and one 4000-kv.-a. 25-cycle 2300-volt machines, which operate in parallel. One night after the steam had been shut off from the turbine and, from all indications on the switchboard, the oil switch opened and the field current cut out, the alternator was found running about twenty minutes afterward without excitation, the oil switch not having opened as indicated on the switchboard. How could the alternator run as a motor without the fields being excited? K. F. M.

The alternator was operating as a motor similar to the way a synchronous motor operates before the field switch is closed, when started from the alternating-current circuit. The field excitation is supplied by lagging current from the line the same as for an induction motor. This is a case where it would appear that the operator was negligent, or the conditions would have been noticed on the instruments at the switchboard.

**Loss of Water from Old Steam-Heating System**—To maintain proper water level in the boiler of an old single-pipe steam-heating system of a public building, it is necessary to supply fresh feed water four or five times a day. What might be causes for such losses of water? A. Y. K.

If the system is provided with a boiler of ordinary proportions and the radiators are fitted with automatic nonreturn air valves, an unusual loss of water might be due to waste of water and steam from imperfect operation of the air valves. A large waste of water might take place from this cause, especially if the circulation of the system is imperfect, and the discharge may occur unnoticed if the air valves are drained by waste pipes run to a sewer or other connection. Other causes for lowering the boiler-water level might be: Fracture of the boiler permitting leakage of steam or water, leakage of joints or pipes, leakage of the blowoff valve, waste of steam from the safety valve, or direct drafts of water or steam from the system by occupants of the building.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# Control of Direct-Current Shunt Motors*

By H. D. James

*SYNOPSIS—An abstract from a series of tests made on 15- and 20-hp. 230-volt direct-current, both constant- and adjustable-speed shunt motors, started from rest by cutting out the starting resistance in one and two steps.*

The present practice in industrial control is the result of the accumulated experience extending over the past 25 years. The theory consists in analyzing the characteristics of the motors to be controlled and designing a controller that will furnish the characteristics not incorporated in the motor design. An analysis of the motor from this standpoint has brought out a number of features that were not generally appreciated.

The application of the controller requires an analysis of the load to be driven by the motor, as well as the characteristics of the latter. The controller must cause the motor to operate through a cycle that is best adapted to the motor load or the machinery to which the motor is connected. The engineer must not lose sight of the fact that the purpose in using a motor and controller is to do certain work, and that he should select a type that will perform this work under existing conditions with the least apparatus and require the minimum of attention.

In the early days of direct-current motors great care had to be taken in starting and in changing the motor speed, to prevent bad sparking and flashing. This led to the practice of using a considerable number of steps in the external armature resistance, to give a small change in amperes per step. The most common form of motor starter, even today, is the faceplate type, this design lending itself readily to the

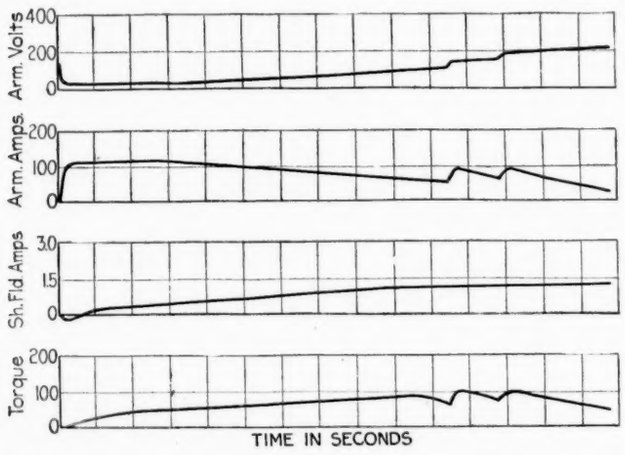



FIG. 1. STARTING CURVES FOR 20-HP. MOTOR TWO-STEP STARTING RESISTANCE 1.35 OHMS

use of a large number of steps. Furthermore, the characteristics of this starter are such that considerable burning would result if there were a large change in current per step, so that a relatively large number of steps is necessary to protect the starter against excessive wear.

The steady improvement in the design of motors and controllers has removed many of the limitations formerly existing. At one time the permissible starting current was seriously limited by the danger of disturbance to the supply voltage. The increased capacity of systems supplying power now permits small and medium-sized motors to start with twice full-load current or even more without disturbing the supply voltage. Many motor applications are made in factories and mills where there is a continual change in the power demand, so that the starting of relatively small motors makes little difference in the total load. However, there still exist a number of applications where starting current is an important feature, such as elevators and some other apparatus used in public buildings. Printing presses, paper machinery and applications of similar nature require special controllers to give a slow start to properly manipulate the product.

Direct-current series and compound motors as large as 20 hp. are in successful operation without the use of an external starting resistance. Shunt motors as large as 15 hp., connected to drum controllers short-circuiting the starting resistance in one step, have been in successful operation for over 10 years.

In order to get a better understanding of the conditions when a direct-current shunt motor is started from rest, a number of tests on standard motors for general purposes, equipped with automatic starters, were made by the author to determine the effect upon the load driven by the motor, the power supplied and the motor operation.

No tests were made upon the controller itself, as commercial controllers that are well able to meet all service requirements are now available. A magnetic contactor controller of modern design should be able to take care of any starting

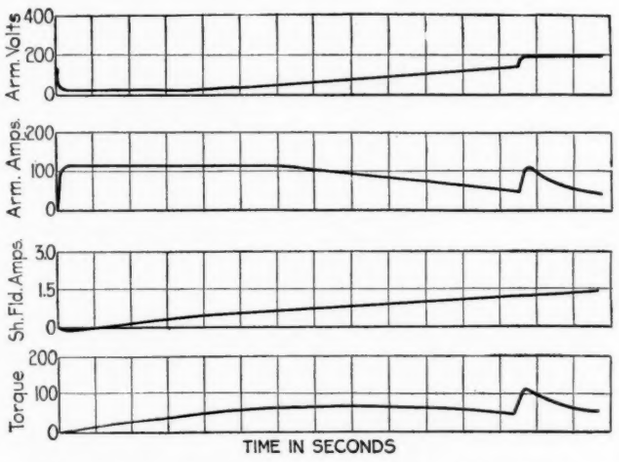



FIG. 2. STARTING CURVES FOR 20-HP. MOTOR ONE-STEP STARTING RESISTANCE 1.35 OHMS

condition that can be met by the motors, without causing undue wear upon any part of the controller.

In all cases the motors used were standard 230-volt shunt-wound direct-current machines. The voltage at the supply circuit dropped a little below this value and varied from 220 to 225 volts. The load in all but two cases consisted of a direct-current generator slightly larger in size than the motor, to which it was belted. The generator exerted no retarding force other than that due to friction and inertia, except where noted. This will represent the majority of loads that a motor of this class will be called upon to start. In one case the field of the generator was excited and the armature short-circuited through sufficient resistance to develop full motor torque at full speed. This condition more nearly represents the starting of a heavy fan or centrifugal pump. The tests on all 20-hp. motors were made with an automatic controller. The switches used on this controller were standard contactors of 125-amp. capacity. The constant-speed shunt motor had its field disconnected in the off-position in all the tests.

Fig. 1 shows the curve obtained from a 20-hp. 750-r.p.m. 230-volt direct-current shunt motor started with 1.35 ohms external armature resistance, which was reduced to 0.35 of an ohm when the counter-electromotive force equaled 120 volts. The second step of resistance was short-circuited when the counter-electromotive force reached 160 volts. This is a very good showing for a two-step automatic starter.

Fig. 2 shows the same motor started with 1.35 ohms external resistance, the resistance being short-circuited in one step, the switch closing when the counter-electromotive force of the motor was 150 volts. This adjustment gives equal current peaks and represents a practical controller.

Fig. 3 shows the curves obtained from a 20-hp. 700-r.p.m 230-volt machine started with 0.765 of an ohm external armature resistance, with one short-circuiting switch. The load on the motor in this case was a prony brake set to give full-load torque. This represents a very difficult starting condition, as the static friction of the brake is considerably in excess of full-load torque. The start, however, was successfully made with one step of resistance.

*Abstract from a paper presented at the midwinter convention of the A. I. E. E., Feb. 16, 1917.

The curves that refer to armature volts, armature amperes and shunt-field amperes were taken from the oscillograph records. The torque curve was plotted by assuming that the field flux was proportional to the shunt-field amperes, except that the negative value of the shunt-field current at starting was neglected and the torque curve started at zero value. While these assumptions are not strictly correct, they serve to show the characteristic shape of the torque curve.

The torque curve shows that the motor will start its load gradually, independent of the value of armature current. A heavy armature current several times the value of the full-load current can be used with safety provided there is no serious effect on the voltage of the supply circuit, which might be objectionable for other reasons. An easy start of the load is very desirable, as there usually is considerable lost motion in the gearing or other mechanical connections between the motor and its load. The sudden application of torque would cause a hammer blow and might injure the machinery. The sudden increase in torque at the time the section of the armature resistance is short-circuited is not so dangerous, so long as a positive torque is maintained and there is no lost motion in the machinery. Figs. 1 and 2 show that very little improvement can be made by using two switches to short-circuit the starting resistance.

The paper also gives the results of many tests on variable-speed direct-current shunt motors starting from rest under various load conditions, by cutting out the starting resistance in one and two steps.

The dynamic-braking tests made indicated that the action of an adjustable-speed motor gives very satisfactory results without the use of additional steps in the dynamic-brake resistance. Under normal operating conditions the friction load would be sufficient to bring the motor quickly to rest from the low speed. In the absence of considerable friction a mechanical brake should be used to obtain a quick stop, as very little dynamic braking can be obtained when the motor reaches low speed.

In the summary the author states that it seems unnecessary with automatic acceleration to use more than one switch to

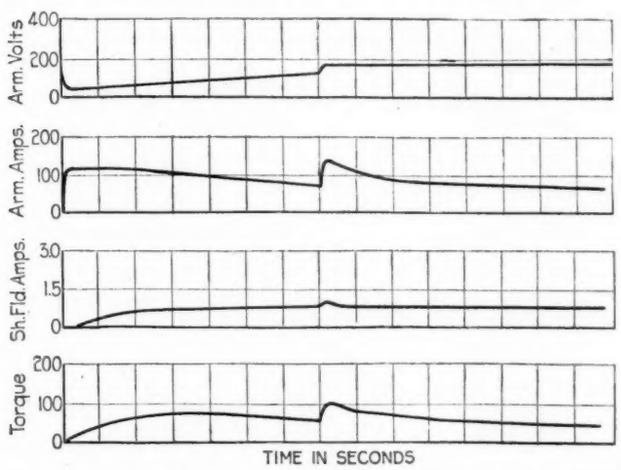



FIG. 3. FULL-LOAD STARTING CURVES FOR 20-HP. MOTOR ONE-STEP STARTING RESISTANCE 0.765 OHM

short-circuit the armature resistance used with small motors, except where special requirements are to be met; that it is practicable to use one switch with motors as large as 15 hp. for general purposes and operate the switch by counter-electromotive force, setting the switch to close at 75 per cent. of normal voltage.

If the motor field is zero or has a small value when the line switch is closed, the starting force is also zero or has only a small value, and it will increase gradually so that the motor or its load will not be subject to a heavy shock or jar when the lost motion in the drive is taken up.

The shunt field of small adjustable-speed motors can be reduced in one step under normal load conditions without fear of undue torque or current; a practice that can be safely followed with 50-hp. motors, and perhaps larger, therefore covering the usual range of sizes for this type of motor.

Most machine-tool motors are always started light, consequently the motor can be started successfully with minimum field strength and the field relay omitted. This will enable the use of the same controller for constant-speed and adjustable-speed motors supplying a separately mounted field rheostat for the latter.

Adjustable-speed motors can use one step of resistance for dynamic braking, as the change in field strength tends to maintain the braking current constant over a considerable range of speed. The use of a "vibrating" or "fluttering" relay is bad engineering for hand-operated field rheostats, unless a "transfer" relay is also used to reverse its action when the motor re-generates. The time required to accelerate to 95 per cent. of speed is very short. In the tests the time did not exceed three seconds.

# How Engineers May Serve Their Country

Successful prosecution of the war depends in a large measure upon proper organization wherein each man will be assigned to the work in which he is best fitted to serve the country. With this in view the National Defense Act was approved last June, authorizing the creation of an Officers' Reserve Corps in the United States Army. There are many engineers anxious to render service in some such capacity, but who do not know the necessary procedure or just where they will fit in. To aid these the five national engineering societies[1] have compiled jointly, for distribution among the membership, information covering the various branches of the service to which this corps will be assigned, the method of enrolling, the necessary qualifications, etc. The following outline is taken from this source:

The branches of the service for which the engineers are best fitted are the Coast Artillery, the Engineer Corps, the Signal Corps, Quartermaster's Department and Ordnance Department.

THE COAST ARTILLERY covers the transporting and mounting of both heavy and light guns, installing and operating power plants in connection with fortifications, moving and installing searchlights, planting submarine mines, placing submarine nets, installing range-finder apparatus, telephone systems, etc.

THE ENGINEER CORPS in time of war attends to military demolitions, the construction and repair of wharves, roads, ferries, bridges and other structures, operation and repair of military railways, the construction of defensive and offensive work, sanitation of camps, etc. The work covers the following special branches of engineering: Bridge engineers, constructional engineers, electrical engineers, highway engineers, hydraulic engineers, irrigation engineers, mining engineers, railroad engineers, sanitary engineers and surveyors.

THE SIGNAL CORPS is divided into two branches, the first covering the transmission of information by means of the telephone, telegraph, wireless and signals, and the second, or Aviation Section, covering aëroplanes, internal-combustion engines for aëroplanes, wireless equipment on aircraft and expert work in pyrotechnics and automatic cameras.

THE QUARTERMASTER'S DEPARTMENT is charged with the duty of providing means of transportation of every character, supplies for the troops, and other materials needed for the army. Textile and chemical engineers are required for the supply and subsistence branches; civil, mechanical, electrical, hydraulic, railroad and marine engineers for the transportation work; and structural engineers for work in connection with buildings, barracks, wharves, water supplies, etc.

THE ORDNANCE DEPARTMENT offers one of the best fields in which mechanical engineers can serve, as it requires men especially trained for the production of munitions. The duties of the ordnance officers are those connected with the direction, management, control and supervision of the work of manufacture, test and repair of ordnance and ordnance stores at arsenals and depots and the inspection and test of such materials when purchased by contract.

Candidates for appointment in the Reserve Corps of Engineers will be examined either for duty with combatant engineer troops and other duties in the service at the front, or for special service on the lines of communication or other points in the rear, including work in connection with the coast defenses. However, officers appointed for the latter work will be subject to assignment whenever needed for the first, or more active, service.

In the time of actual hostilities the President may order members of the Officers Reserve Corps, subject to physical examination, to temporary duty with the regular army or as officers in the volunteer or other organizations. While reserve officers on such duty, they shall be entitled to the pay and allowances of the corresponding grades in the regular army. The pay of a major is $3000 a year, that of captain $2400, that of first lieutenant $2000, and second lieutenant $1700. An officer has to purchase his uniform and personal equipment and pay for his food.

[1]The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining Engineers and the American Institute of Consulting Engineers.

After having decided in which department he is best fitted to enroll, one should apply for application blanks to the secretary of the engineering society to which he belongs, or to the Adjutant General, War Department, Washington, D. C. The application blanks for the Coast Artillery, when filled out, should be sent to Chief of Coast Artillery; for the Corps of Engineers to the Chief of Engineers; for the Signal Corps to the Chief Signal Officer; for the Quartermaster's Department to the Quartermaster General, and for the Ordnance to the Chief of Ordnance; all at the War Department, Washington, D. C. The examinations are both physical and mental, the subjects covered differing with each branch of the service.

The following publications relate to subjects covered by the examinations: "Infantry Drill Regulation," issued by the Superintendent of Documents, 35c.; "Field Service Regulation," issued by the Superintendent of Documents, 60c.; "Engineers' Field Manual," issued by the Superintendent of Documents, $1; "Bulletin No. 4, Vol. 1, Chief of Staff," issued by Adjutant General; "Army Regulations, 1913," issued by the Superintendent of Documents, 60c.; "Manual of Court Martial," issued by the Superintendent of Documents, 65c.; "Army Transport Regulations," issued by the Superintendent of Documents, 35c.; "Rules of Land Warfare," issued by Adjutant General, 50c.; "Coast Artillery Drill Regulation," issued by Superintendent of Documents, 60c.

The books issued by the Superintendent of Documents may be obtained by addressing that official at the Government Printing Office, Washington, D. C. Those issued by the adjutant General may be obtained by addressing that official in care of the War Department, Washington, D. C.

### SERVICE IN THE NAVY

Service in the navy is possible by enlistment in the navy, in the Naval Militia, and by enrolling as an officer or man in the Naval Reserve. Civilians are being employed as mechanics, draftsmen, etc., in the navy yards. The Departments of Yards and Docks, Construction and Repair, and Steam Engineering are not enrolling officers; hence engineers competent to enroll as officers can do so only by joining some branch of the Naval Reserve, where, after proper examination, they will be taken on trial by giving them provisional rank. After a period of three months' training, such provisional officers will again be examined, and if the result is satisfactory, they will be confirmed in this provisional appointment and given actual rank. To be given a provisional rating in the navy a man must have the technical knowledge of the corresponding rating in the navy, and to be confirmed in a provisional rating a man must, in addition, have a fair knowledge of naval discipline and customs. To be advanced in rating a man must have the technical knowledge of the corresponding rating in the navy and a good knowledge of naval customs and methods.

### CLASSES OF THE NAVAL RESERVE

The Naval Reserve force is divided into six classes, covering Fleet Naval Reserve, Naval Reserve, Naval Auxiliary Reserve, Naval Coast Defense Reserve, Volunteer Naval Reserve, Naval Reserve Flying Corps. The first of these requires previous service in the navy, the second experience in the merchant marine, the third service on American vessels listed by the Navy Department as desirable for auxiliary use in time of war. The Volunteer Naval Reserve is composed of those members of the Naval Reserve force who obligate themselves to serve in the navy in any one of the classes without pay in time of peace. Citizens skilled in flying, or in the design and building of aircraft are eligible to the Naval Reserve Flying Corps.

The Naval Coast Defense Reserve is the branch in which engineers will probably find greatest service at the present time. However, enlistment in this branch of the service must be for a period of four years. A patrol-boat unit consists of an ensign, a quartermaster, an engineer and four seamen. The ensign and the engineer must be experienced, the former with coastwise navigation, and the latter with the handling of the engine.

## Editors Indorse President's Proclamation

The Editorial Conference of the New York Business Publishers Association at a luncheon on Apr. 16 passed the following resolution:

Resolved: The members of the Editorial Conference of the class journals of New York City here assembled, are glad to respond to President Wilson's appeal in his proclamation of Apr. 15 and will do all in their power to lead and inspire the industries they represent to render that patriotic service to the Nation which the President has requested.

## New York Boiler Code Hearing

The State Industrial Commission of the Department of Labor for the State of New York held the last of six public hearings in April on the proposed rules for the construction, installation, operation and maintenance of steam boilers.

The rules for the most part are, for new installations of power boilers, the same as appear in the Boiler Code of the American Society of Mechanical Engineers. No change in the proposed New York Code is made from the New Installations part of the A. S. M. E. Code.

The Code, as it will be put in force by the Industrial Commission, will apply to factories only. All boilers for steam-generating purposes and for heating factories will be subject to a regular inspection and external inspection each year and all boilers used for generating steam or heat for mining, tunneling or quarrying purposes shall be inspected externally at least once in six months and subject to a regular internal inspection each year, and must be reported on Jan. 1 of each year.

Fifteen days' notice for an internal inspection under hydrostatic-pressure test is given to the owner to prepare the boiler for such inspection.

According to Rule 803, if steam or hot water is leaking into the boiler, the source of such leakage shall be discontinued. Rule 804 provides that coverings of any kind or enough of it shall be removed so that the size and pitch of the rivets and such other data may be determined.

Boilers subject to periodic inspection by duly authorized insurance companies are exempt from regular annual inspection by the Industrial Commission.

The insurance company's inspectors who inspect boilers operated in the state shall hold certificates of competency issued by the commission. A person holding a certificate of competency as an inspector of steam boilers for a state that has a standard of examination equal to the standard set by the Industrial Commission of the State of New York shall, upon written request of a duly authorized boiler-insurance company, by whom such person is employed, be granted a certificate of competency and a commission as an inspector of steam boilers for the State of New York without further examination.

The discharge of safety valves, blowoff pipes or other outlets shall be so located that there will be no danger from scalding.

Safety valves, try-cocks, water column and water blowoffs on boilers operated at a pressure of more than fifteen pounds shall be tested daily when the boiler is in operation.

All patches on a boiler shell or drum, which exceed 24 in. in length measured on a line parallel to the longitudinal seam and between the center lines of the extreme rivet holes, shall be calculated for safe working pressure from said patch seam, the efficiency of which shall be determined in the usual manner. The efficiency of the patch seam may then be increased by multiplying said efficiency by a factor which is determined by the angularity of the inclined patch seam to the girth seam, according to the following table:

| Angle | Factor | Angle | Factor |
|---|---|---|---|
| 30 degrees | 1.51 | 50 degrees | 1.20 |
| 35 degrees | 1.42 | 55 degrees | 1.15 |
| 40 degrees | 1.34 | 60 degrees | 1.11 |
| 45 degrees | 1.27 | 65 degrees | 1.08 |

At the hearing these general rules were not changed or debated upon.

One change in the standard official symbol stamp of the American Society of Mechanical Engineers, or rather from the Boiler Code, was suggested. This stamp, as at present, gives a space for the name of the state, the number of the boiler and the name of the builder. The suggestion made, and which the committee will consider, will be an inclusion in such stamp of the year the boiler was made and the pressure for which it was made.

In the section of the Code relative to existing installations some changes have been made, the most important of these, perhaps, being the factors of safety, which are as follows, as they appear in the New York proposed code:

One year after these rules become effective the boilers of butt and double-strap construction shall not be operated without a factor of safety of at least 4 by the formula, paragraph 378. Five years after these rules become effective the factor of safety shall be at least 4.5. In no case shall the maximum allowable working pressure on old boilers be increased unless they be operated at a lesser pressure than would be allowable for new boilers, in which case the changed pressure shall not exceed that allowable for new boilers of the same construction.

The lowest factor of safety used for boilers the shells or drums of which are exposed to the products of combustion

and the longitudinal joints of which are of riveted construction shall be not less than the following: 4¼ for boilers not over 5 years old; 4½ for boilers over 5 and not over 10 years old; 4¾ for boilers over 10 and not over 15 years old; 5 for boilers over 15 and not over 20 years old.

For each 5 years thereafter the factor of safety shall be increased by not less than 0.5, provided, however, that after a thorough internal and external inspection and a hydrostatic-pressure test of 1½ times the pressure allowed, during which no distress or leakage develops, the pressure allowed may be continued at a factor of safety of 5.

The owner or user of such boiler shall prepare it for hydrostatic-pressure tests by uncovering the riveted joints.

The lowest factor of safety for boilers the shells or drums of which are not exposed to the products of combustion and the longitudinal joints of which are of lap-riveted construction shall be not less than the following: 4 for boilers not over 10 years old; 4¼ for boilers over 10 and not over 15 years old; 4½ for boilers over 15 and not over 20 years old; 5 for boilers over 20 years old.

For each 5 years thereafter the factor of safety shall be increased by not less than 0.5, provided, however, that after a thorough internal and external inspection and a hydrostatic-pressure test of 1½ times the pressure allowed, during which no distress or leakage develops, the pressure allowed may be continued with a factor of safety of 5. Second-hand stationary boilers, by which are meant boilers where both the ownership and location are changed and which are not less than 10 years old and have longitudinal joints of lap-riveted construction, shall have a factor of safety of at least 5½ one year after the rules become effective unless constructed in accordance with the rules of Part 1, relative to new installations, when the factor of safety must be 5.

Cast-iron headers and mud drums are not allowed on water-tube boilers the tubes of which are secured to cast-iron or malleable-iron headers for which cast-iron mud drums are not to be allowed a pressure in excess of 160 pounds.

The maximum allowable working pressure on steam-heating boilers shall not exceed 50 lb. per sq.in. on a boiler used exclusively for low-pressure steam heating.

There was considerable discussion over this paragraph. This discussion arose because the New York City engineers' and firemen's license law makes a license compulsory for the operator of a boiler carrying 10-lb. pressure. Those objecting to the paragraph felt that the enforcement of such a paragraph would mean that many low-pressure boilers operating between 10 and 15 lb. and which now require a licensed man, according to the New York City law, would not, upon the passage of this paragraph in the Code, require licensed men. It was pointed out by the committee and by the board that the Code as here put forth related solely to construction and not to the licensing of engineers or firemen.

### LIVELY DISCUSSION ON LAP JOINT

The most heated discussion occurred over paragraph 384, which is from the A. S. M. E. Boiler Code without any change, and reads: "No pressure shall be allowed on a boiler on which a crack is discovered along the longitudinal riveted joint."

In explanation of this paragraph it may be well to state that its purpose is to weed out, in as equitable manner as possible, the lap-seam boiler. A representative of a boilermakers' union contended that the enactment of such a paragraph would mean serious losses to the boilermakers because it would make unavailable any opportunity to do work on a boiler having a defect of this character, for the reason that, as interpreted, a boiler developing such a crack would be thrown out of service for all time.

The lap-seam boiler received a vigorous defense by Michael Fogarty, a boilermaker in New York City, stating as his chief point that it was not so much the type of joint that was at fault as it was the material in the plate. To this T. T. Parker, chief boiler inspector of the Fidelity and Casualty Co., countered, with the point that he agreed, but that inasmuch as it was the plate, it would be dangerous to make a patch at such a point where the metal was brittle, which he claimed was the case, as the crack was indicative of brittle metal. The committee will take up this question and others at its final meeting, soon to be held.

The tensile strength of steel and wrought-iron plates for boiler shells must be taken at 55,000 lb., 45,000 lb. for wrought iron and 18,000 lb. for cast iron.

The commission recommends, but does not make compulsory, the use of automatic nonreturn stop valves in the steam lines from boiler. In response to a question as to why automatic stop valves were not made compulsory instead of being recommended, the commission answered that some such valves were dangerous appendages on boilers. In other words, the reason the use of automatic stop valves was not made compulsory was purely commercial.

The commission will hold a final meeting some time early in May, the date not having been decided. The public hearing on the Boiler Code was held in the commission's quarters, 230 Fifth Avenue.

## PERSONALS

**W. F. Schaphorst** has established an engineering advertising service office in the Woolworth Bldg., New York City.

**D. H. Heron,** for the past nine years chief engineer of power, light and heat for the Titusville Iron Co., Titusville, Penn., has resigned to accept the position as general foreman of the Bradley Pulverizing Co., Allentown, Penn.

**Wallace H. Martin,** formerly instructor of mechanical engineering at the University of Minnesota, Minneapolis, Minn., has become associated with the mechanical-engineering department of the Pennsylvania State College, State College, Penn.

**F. H. Schubart,** who was formerly district manager for the Wheeler Condenser and Engineering Co., is now associated as assistant chief engineer of power plants with John Hunter, of the Union Electric Light and Power Co., St. Louis, Mo.

**Gustaf Akurlund and George W. Semmes,** formerly chief engineer and assistant chief engineer respectively of the Standard Gas Power Co., have established a joint consulting and contracting engineering business at 17 Battery Place, New York City.

## ENGINEERING AFFAIRS

**The Philadelphia Section of the Association of Iron and Steel Electrical Engineers** will hold a meeting on May 5, at the Majestic Hotel. G. E. Stoltz will talk on "Some Recent Applications of Electricity in the Steel Industry."

**The American Society of Safety Engineers** will hold its regular monthly meeting on Apr. 25, at the Engineering Societies Building, 25 West 39th St., New York City. Col. Lewis T. Bryant, Commissioner of Labor, State of New Jersey, will deliver a lecture on "Safety."

**The Pittsburgh Section of the Association of Iron and Steel Electrical Engineers** will hold a meeting on May 19 at the Fort Pitt Hotel, under the auspices of the Power Committee, with W. O. Oschmann as chairman. The subject will be, "Power Cost Accounting Systems as Practiced by Several Steel Mills in the Pittsburgh District."

**Chicago N. A. S. E. Banquet**—On the evening of April 14, the four Chicago Associations of the National Association of Stationary Engineers held an informal banquet in the Red Room of the Hotel La Salle. The national officers were present and in all 322 attended the banquet. John F. McGrath, acting as toastmaster, called upon the officers and others, all of whom responded briefly with short and appropriate talks. Vaudeville entertainment added to the pleasures of the evening. The gathering was a great success.

**Lowell Association No. 17, N. A. S. E.,** held its annual smoker on Saturday, Apr. 14. The event was to celebrate the removal of the Association to its new and improved meeting rooms at 15 Palmer St. Many delegations from Boston and near-by cities were present. The festivities began with an address by past national president Herbert E. Stone. Brief speeches were also made by Fremont Eggleston, president of the Commercial Engineers Association; Joseph Eccleston, vice-president of the New England States Association of Stationary Engineers; George Hayes, chairman of the Educational Committee of the New England States, and James H. Henderson, secretary of the state's association. An enjoyable entertainment was given by Herbert Self, Peerless Rubber Co., Joseph McKenna, Jenkins, Bros. and Jack Armour, "Power," all of New York and James Donnelly and James Daly of Lowell. All kinds of good things to eat, drink and smoke were served at intervals. President James Markhaw made a congenial master of ceremonies and past national president Theodore N. Kelsey helped to keep the "boys" in order.

# THE COAL MARKET

**Boston**—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

| | Circular[1] | | Individual[1] | |
|---|---|---|---|---|
| | Apr. 21, 1917 | One Year Ago | Apr. 21, 1917 | One Year Ago |
| Buckwheat | $3.40@4.40 | $3.05@3.20 | $6.50@6.75 | $3.25@3.50 |
| Rice | ..... | 2.50@2.65 | 5.50@5.75 | 2.70@2.95 |
| Boiler | ..... | ..... | 4.25@4.50 | ..... |
| Barley | 2.65@3.65 | 2.20@2.35 | 4.15@4.40 | 2.35@2.60 |

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

| | F.o.b. Mines* | | Alongside Boston† | |
|---|---|---|---|---|
| | Apr. 21, 1917 | One Year Ago | Apr. 21, 1917 | One Year Ago |
| Clearfields | $4.50@5.25 | $1.40@1.90 | $8.75@9.25 | $4.25@5.00 |
| Cambrias and Somersets | 4.75@5.50 | 1.60@2.10 | 9.00@9.50 | 4.60@5.40 |

Pocahontas and New River, f.o.b Hampton Roads, is $5.50@5.75, as compared with $2.75@2.85 a year ago; on cars Boston price is $11.

*All-rail rate to Boston is $2 60. †Water coal.

**New York**—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

| | Circular[1] | | Individual[1] | |
|---|---|---|---|---|
| | Apr. 21, 1917 | One Year Ago | Apr. 21, 1917 | One Year Ago |
| Buckwheat | $3.70@3.80 | $2.75 | $5.00@5.75 | $3.00@3.25 |
| Rice | 3.00@3.30 | 2.25 | 4.25@4.50 | 2.15@2.25 |
| Barley | 2.50@2.80 | 1.75 | 3.25@3.40 | 2.00@2.10 |

BITUMINOUS

| | South Amboy | Port Reading | Mine Price |
|---|---|---|---|
| Clearfield | $6.25@6.50 | $6.25@6.50 | $4.25@4.50 |
| South Forks | 6.50@6.75 | ..... | 4.50@4.75 |
| Nanty Glo | 6.50@6.75 | ..... | 4.50@4.75 |
| Somerset | 6.25@6.50 | 6.25@6.50 | 4.25@4.50 |
| Quemahoning | 6.50@6.75 | 6.50@6.75 | 4.50@4.75 |

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

**Philadelphia**—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

| | Line | | Tide | |
|---|---|---|---|---|
| | Apr. 21, 1917 | One Year Ago | Apr. 21, 1917 | One Year Ago |
| Buckwheat | $2.50 | $1.55 | $3.40 | $2.30 |
| Rice | 2.00 | .90 | 3.00 | 1.80 |
| Boiler | 1.80 | .... | 2.90 | .... |
| Barley | 1.50 | .55 | 1.75 | 1.30 |

**Pittsburgh**—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

| | Apr. 21, 1917 | One Year Ago |
|---|---|---|
| Slack | $3.25@3.50 | $1.05@1.15 |
| Mine-run | 3.25@3.50 | 1.20@1.30 |
| ¾-in. | 3.25@3.50 | 1.30@1.40 |

Add 40c. per ton for freight charge to Pittsburgh.

**Chicago**—Current price per net ton f.o.b. mines are as follows:

| | Williamson and Franklin Counties | Saline and Harrisburg | West Virginia Smokeless | Springfield | Clinton and Sullivan Counties |
|---|---|---|---|---|---|
| Steam lump | $2.75@3.00 | $2.75@3.00 | $3.50@4.00 | $2.25@2.50 | $2.00@2.25 |
| Lump | 3.00@3.25 | 3.00@3.25 | 3.75@4.25 | 2.50@2.75 | 2.75@3.00 |
| Egg | 3.00@3.25 | 3.00@3.25 | 3.75@4.25 | 2.50@2.75 | 2.75@3.00 |
| Nut | 3.00@3.25 | 3.00@3.25 | ..... | 2.50@2.75 | 2.75@3.00 |
| No. 1 nut | 3.00@3.25 | 3.00@3.25 | ..... | 2.50@2.75 | 2.75@3.00 |
| No. 2 nut | 3.00@3.25 | 2.75@3.00 | ..... | ..... | ..... |
| No. 3 nut | 2.75@3.00 | 2.50@2.75 | ..... | ..... | ..... |
| No. 1 washed | 3.00@3.25 | ..... | ..... | ..... | ..... |
| No. 2 washed | 3.00@3.25 | ..... | ..... | ..... | ..... |
| Mine-run | 2.50@2.75 | 2.50@2.75 | 3.50@4.00 | 1.75@2.00 | 1.75@2.25 |
| Screenings | 2.50@2.75 | 2.50@2.75 | ..... | 1.75@2.00 | 1.75@2.25 |

Hocking lump, $3.50@3.75; splint lump, $3.50@3.75.

**St. Louis**—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

| | Williamson and Franklin Counties | | Mt. Olive and Staunton | | Standard | |
|---|---|---|---|---|---|---|
| | Apr. 21, 1917 | One Year Ago | Apr. 21, 1917 | One Year Ago | Apr. 21, 1917 | One Year Ago |
| 6-in. lump | $2.50@3.00 | $1.25@1.50 | $1.75 | $1.25@1.40 | $1.50@1.75 | $1.10@1.15 |
| 2-in. lump | ..... | 1.20@1.40 | .... | 1.15@1.25 | 1.35@1.50 | .85@1.00 |
| Steam egg | 2.50@3.00 | 1.20@1.40 | 1.75 | 1.15@1.25 | 1.35@1.50 | .85@1.00 |
| Mine-run | 2.00@2.25 | 1.05@1.20 | 1.75 | 1.05@1.15 | 1.35@1.40 | .80@1.00 |
| No. 1 nut | 2.50@3.00 | 1.20@1.50 | 1.75 | 1.25@1.40 | 1.50@1.75 | .85@1.00 |
| 2-in. screen | 2.00@2.25 | .90@1.10 | 1.75@2 | .85@1.00 | 1.35@1.50 | .85@1.00 |
| No. 5 washed | 2.00@2.25 | .90@1.10 | .... | .85@1.00 | ..... | .85@1.00 |

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

**Birmingham**—Current prices per net ton f.o.b. mines are as follows:

| | Mine-Run | Washed | | Mine-Run | Washed |
|---|---|---|---|---|---|
| Pratt | $3.25@3.50 | ..... | Carbon Hill | $2.75@3.25 | $3.00@3.25 |
| Big Seam | 2.75@3.00 | $3.00@3.25 | Cahaba | 3.25@3.50 | ..... |
| Black Creek | 3.25@3.50 | 3.50 | | | |

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

# PROPOSED CONSTRUCTION

**Alta., Champion**—A lighting plant will be installed in the new opera house, which will furnish lighting service for the town. W. A. Carmichael, Secy.

**Calif., Bythe**—Floyd Brown, Los Angeles, has applied to the State Railroad Comn. for permission to install an electric-light and power plant.

**Colo., Englewood**—City plans election to vote on bonds to build an electric-lighting plant.

**Fla., St. Cloud**—City Council is considering installing an electric-light plant.

**Ga., Folkston**—J. W. Buchanan will install a power plant to furnish electricity to the city and energy to the manufacturing plants.

**Ga., Thomasville**—City will hold an election Apr. 27 to vote on $160,000 bonds part of which will be used for an electric-light plant. W. Miller, Engr.

**Idaho, Pocatello**—City is considering plans to build an electric-light and power plant. J. H. Giles, Engr.

**Ill., Chicago**—The Commonwealth Edison Co., 72 West Adams St., will soon receive bids for alterations to its substation. Von Holst & Fyfe, 72 West Randolph St., Arch.

**Kan., Pleasanton**—City is considering installing an electric-light plant.

**Ky., Adairville**—The Electric Equipment Co., Nashville, is reported to be interested in an electric-light plant to be installed in this city.

**La., Rayne**—City will sell bonds to install an electric-lighting plant.

**Minn., Crosby**—The Village Council is considering plans to install an electric-lighting plant.

**Minn., Farwell**—The Glenwood Electric Light, Heat and Power Co. has been granted a franchise to install and operate an electric-light and power plant. C. Dickerson, Glennwood, Supt.

**Miss., Tylertown**—The Tylertown Light and Power Co. will construct a power station and will install an additional generating unit. W. A. Boyd, Owner.

**Mont., Eureka**—City plans to hold election to vote on question of granting franchise to J. J. Tetrault and associates, who plan to install a hydro-electric plant on Grave Creek. Estimated cost, $60,000.

**N. J., Newark**—The Overbrook Hospital will install new boilers and accessory equipment under the supervision of the United Construction and Supply Co., 61 Broadway, New York. Estimated cost, $59,928.

**N. J., Trenton**—The J. A. Roebling's Sons Co., South Broad and Canal Sts., will construct a power plant at its wire-rope manufacturing plant on Canal St.

**N. J., Trenton**—The Trenton Gas and Electric will build two 1-story additions to its plant on New York Ave.

**N. Y., Argyle**—City voted bonds to install an electric-lighting system.

**Ohio, Canton**—The Republic Stamping and Enameling Co. will construct a power plant at its west side plant.

**Okla., Butler**—City voted $6000 bonds to install an electric-lighting system.

**Okla., Capron**—City plans to install an electric-lighting system.

**Ont., Brussels**—Town plans a hydro-power plant.

**Pa., Altoona**—The Pennsylvania Hydro-Electric Co., controlled by the Pennsylvania Light and Power Co., has applied to the Public Service Comn. for permission to issue $36,000 bonds to improve and extend its plant. E. B. Greene, 1412 11th Ave., Gen. Supt.

**Pa., Chester**—The McCausland Engineering Co., Pennsylvania Bldg., will install a 1-story, 58 x 82-ft. power plant at its new factory on 5th St.

**Pa., Harrisburg**—The Harrisburg Light and Power Co., 22 North 2d St., plans to make further improvements including the installation of mechanical stokers to cost about $100,000, and line extensions. L. L. Ferree, Supt.

**Pa., New Castle**—The New Castle Electric Co., controlled by the Republic Railway and Light Co., has asked the Public Service Comn. for permission to issue $9000 bonds to improve its plant. C. O. Bailey, Youngstown, Ohio, Pur. Agt.

**Tenn., Alexandria**—City will install an electric-lighting system.

**Tenn., Trezevant**—City plans to hold an election to vote on $7500 bonds to install an electric-light plant.

**Va., Richmond**—The James River & Kanawha Power Co. is having plans prepared for a power plant at the falls of the James River. Estimated cost, $250,000. A. J. Bradley, P. O. Box 421, Pres.

**Wash., Ephrata**—M. Nelson is having plans prepared for an electric-light and power plant. About $10,000. Transmission lines will be extended to Soap Lake.

**Wash., Othello**—City will install an electric-light and power plant.

**Wash., Seattle**—City is revising plans for an addition to the steam auxiliary plant at the municipal power plant. Bids will be received about the latter part of April. J. D. Ross, Lighting Supt.

**Wash., Tekoa**—The City Council has appointed a committee to obtain estimates for an electric-lighting plant.

**W. Va., Wheeling**—The American Gas and Electric Co. will construct a new power house. M. B. Felamann, 30 Church St., New York, Ch. Engr.

**Wis., Ashland**—The L. E. Myers Co. is having plans prepared for improvements at its electric-light and power plant.

**Wis., Stevens Point**—The Jackson Milling Co. is considering plans for a hydro-electric plant to transmit electricity to its paper mill in Biron.